Fisheries and Oceans Canada | Pêches et Océans Canada

Canadian Stock Assessment Secretariat
Research Document 99/83

Not to be cited without
Permission of the authors[1]

Secrétariat canadien pour l'évaluation des stocks
Document de recherche 99/83

Ne pas citer sans
Autorisation des auteurs[1]

Status of Atlantic salmon (*Salmo salar* L.) in Campbellton River, Notre Dame Bay (SFA 4), Newfoundland in 1998

by

P. R. Downton and D. G. Reddin

Science Branch
Department of Fisheries and Oceans
P. O. Box 5667
St. John's, Newfoundland
A1C 5X1

[1] This series documents the scientific basis for the evaluation of fisheries resources in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

[1] La présente série documente les bases scientifiques des évaluations des ressources halieutiques du Canada. Elle traite des problèmes courants selon les échéanciers dictés. Les documents qu'elle contient ne doivent pas être considérés comme des énoncés définitifs sur les sujets traités, mais plutôt comme des rapports d'étape sur les études en cours.

Research documents are produced in the official language in which they are provided to the Secretariat.

Les documents de recherche sont publiés dans la langue officielle utilisée dans le manuscrit envoyé au secrétariat.

ISSN 1480-4883
Ottawa, 1999

Canada

Abstract

The status of Atlantic salmon in Campbellton River in 1998 was determined from the number of salmon counted through a portable fish counting weir (fence) located on the main stem just above head of the tide as well as from biological data collected from the recreational fishery. The assessment was conducted in response to major management changes that were introduced in 1992 and continued into 1998. Stock status is defined in comparison of the actual egg deposition to conservation requirements. Specifically, there was a moratorium on the commercial Atlantic salmon fishery in insular Newfoundland and restrictions were placed on recreational fishing in each Salmon Fishing Area. In 1998, adult returns were 3,275 small and 402 large salmon compared to the average of 3,059 small and 306 large salmon, 1993-98. Historical records indicate that circa.1800, about 12,000 adult salmon were captured at a harvesting weir. The freshwater survival from eggs to smolt for the 1993 year class was 0.68%. The percent of the conservation egg requirement achieved for Campbellton River in 1998 was 317%. On average, for the period of 1993-98, Campbellton River achieved 275% of its conservation requirement.

Résumé

L'état du saumon de l'Atlantique de la rivière Campbellton en 1998 a été défini à partir du nombre de saumons dénombrés à une barrière de comptage portative installée sur le cours principal de la rivière tout juste en amont de la limite de marée, et de données biologiques de la pêche récréative. L'évaluation a été effectuée suite à d'importantes modifications de gestion apportées en 1992 et maintenues en 1998. L'état du stock est défini en comparant la ponte aux besoins de conservation. Plus précisément, un moratoire a été imposé à la pêche commerciale du saumon de l'Atlantique de l'île de Terre-Neuve et des restrictions ont été appliquées à la pêche récréative dans toutes les zones de pêche du saumon. En 1998, les remontées d'adultes étaient de 3 275 petits et 402 grands saumons comparativement à une moyenne de 3 059 petits et 306 grands saumons pour la période 1993-1998. Les registres montrent que 12 000 saumons adultes ont été récoltés dans une pêcherie fixe vers 1800. La survie en eau douce du stade de l'oeuf à celui de saumoneau a été de 0,68 % pour la classe d'âge de 1993. Le pourcentage de la ponte nécessaire à la conservation à été de 317 % dans la Campbellton en 1998. En moyenne, les besoins de conservation de la rivière ont été atteint à 275 % pendant la période 1993-1998.

Introduction

The Campbellton River (Indian Arm River) flows in a northeasterly direction emptying into the sea at Indian Arm, Notre Dame Bay. In total, Campbellton River has a drainage area of approximately 296 km^2 with an axial length of 40.22 km (Porter et al. 1974) and is about the average size for salmon rivers along the northeast coast of insular Newfoundland. The drainage area is also a protected water supply, which provides domestic water for the town of Campbellton. The river which is located in Salmon Fishing Area (SFA) 4 (Fig. 1), is in a very productive salmon zone which, on average, accounts for about 23 percent of all salmon landed by the recreational fishery in the province of Newfoundland (Table 1). During the early to mid-1980s, Campbellton River attracted an average of just over 2,000 rod days. However in following years, angling effort declined by 50 percent increasing again after 1992 to approximately 1600 rod days (Table 2a). Catches in the commercial salmon fishery between 1984 to 1990 declined considerably for the island of Newfoundland and the commercial fishery was closed in 1992. In SFA 4, the commercial catch in 1991 experienced a 64% and 47% drop in catch for small and large salmon, respectively, when compared to the mean catches in 1984-90, for the same area (Table 2b).

In this paper, we examine the status of Atlantic salmon in Campbellton River. Counts obtained from smolt and adult counting fences are used in conjunction with recreational fishery data and biological characteristic data to calculate total river returns and spawning escapements. Status of the Atlantic salmon stock is evaluated against a conservation requirement which is calculated in terms of available fluvial and lacustrine habitats.

Management Measures

In 1992, a major change was introduced in the management of Atlantic salmon. A five-year moratorium was placed on the commercial fishery in insular Newfoundland, while in Labrador fishing continued under quota until 1998 when the fishery was closed. In addition, a commercial license retirement program went into effect in both insular Newfoundland and Labrador reducing the number of licenses by 96%. These measures were still in effect in 1998. All of these management measures were aimed at increasing river escapements, thus contributing to the increased numbers of upstream migrating adult salmon. Also, a moratorium on the Northern Cod Fishery in NAFO Divisions 2J,3KL was implemented in early July of 1992 and in NAFO Division 3Ps in 1993 which should have resulted in the elimination of salmon by-catch in cod fishing gear in SFAs 1-9 in 1992 followed by SFAs 10 - 14A in 1993. The commercial cod fishery moratorium continued in 1998 with exception of a limited commercial fishery in 3Ps and recreational handline fishery. An ongoing cod test fishery (Sentinel Survey) takes place at various locations around the island, however by-catch results indicate no impact on the salmon marine populations. A study of the salmon bycatch in the capelin fishery was undertaken by DFO in 1983 in several major bays around Newfoundland. The results of this study indicated that very few salmon smolts were caught as a bycatch in this fishery (Reddin and Downton, unpublished report 1983). Therefore, it is

assumed that the by-catches of the two major fisheries around the island have had little impact on salmon populations since 1991.

In the recreational fishery, in 1992 and 1993, a quota on the number of fish that could be retained was introduced in each Salmon Fishing Area (SFA). The quota was assigned for an entire SFA and was not administered on an individual river basis. Only hook-and-release fishing was permitted after the quota was caught. In 1994, SFA recreational fishery quotas were eliminated. In place of quotas, for insular Newfoundland, the season bag limit for retained small salmon was lowered from eight to six fish, three to be caught prior to July 31 and three after that date up to the end of the fishing season. Hook-and-release fishing was permitted throughout the fishing season. These measures remained in effect in 1997 and applied to salmon angling on Campbellton River. However, due to low salmon returns in 1997, all rivers were closed to retention as of July 28 and then on August 1st both retention and hook and release fisheries were closed which remained in effect to the end of the season. In 1998, the retention of one fish was permitted during the initial part of the fishing season until an in-season review in July was completed allowing another 3 fish to be retained, thus giving a 4 fish retention quota. Also, for 1998 season as in previous years, retention of large salmon was not permitted in insular Newfoundland and hook and release fishing was reduced to two fish per day.

Methods

ANGLING FISHERY

Catch and effort data for Campbellton River as well as other rivers in Newfoundland and Labrador were collected by Department of Fisheries and Oceans (DFO) Fisheries Officers until 1996. Beginning in 1997, a License Stub Return System was used to collect data directly from anglers in all SFAs of Newfoundland and Labrador with the exception of SFAs 1 and 2 in Labrador (O'Connell et al. 1998). Data for both methods were processed by DFO Science Branch staff. Procedures for the collection and compilation of angling data are described by Ash and O'Connell (1987) and O'Connell et al. 1998.

UNRECORDED MORTALITIES

Complete understanding of all life history factors including mortality is an important part of any stock assessment (Ricker 1975). Mortalities due to fishing but not recorded as part of the catch statistics have been defined as non-catch fishing mortalities (Ricker 1976). Non-catch fishing mortalities should include those fish killed due to both illegal and legal fishing activities. Legal fishing mortalities of salmon in Newfoundland and Labrador include catches in food (First Peoples), angling, sentinel and commercial fisheries. Illegal mortalities include poaching in both the freshwater and marine environments. Illegal mortalities by their very nature are extremely difficult to quantify. An indirect method of quantifying removals by illegal means and by predators is by observation of net marks, scars and abrasions on salmon

at enumeration facilities. During 1993-98, fish with visible marks were observed at Campbellton River by closed-circuit video and visual observations. These observations provide a minimum estimate of the incidence of marked fish because light conditions or minor scarring could render some marks invisible. The incidence of marks does not quantify unrecorded mortalities but does provide an indication that illegal or legal bycatches of salmon and/or predation was likely occurring at sea for Campbellton River salmon prior to their entry into freshwater.

Additionally, quantification of mortalities arising from the practice of hook and release fishing are also important for accurately assessing spawning escapement. To date, there have been no definitive hook and release mortality studies on salmon in Newfoundland. However, studies elsewhere have shown that mortality rates of hooked and released 'bright' salmon are low depending in part on the skill of the angler, method of fishing and length of time the fish are handled, length of residence of the salmon in freshwater prior to angling, and most important the temperature of the water. Recent studies in New Brunswick indicate that rates of 10% are possible (Brobbel et al. 1996; Dempson et al.1998; Anon.1998). Another source of unrecorded mortalities is from poaching above the counting fence. Due to the illegal nature of poaching no enumeration of the number of salmon caught illegally on Campbellton River is possible. However, these additional removals potentially result in a lower than indicated number of spawners. Thus, calculation of spawning escapement based on counts at the fence should be regarded as potential only.

SMOLT AND ADULT SALMON COUNTS

Standard conduit smolt and adult counting fences were installed according to the description in Anderson and McDonald (1978). The smolt fence was placed in the main stem of the river on May 13 th, 1998 just above the site of the Old Horwood Dam, which was located approximately 345 m upstream from the highway bridge situated at the mouth of the river (Fig. 2). The entire fence was comprised of 38 sections, each 3 m in length, and a standard 2 x 2 m smolt trap installed across a 68 m section of the river. The substrate was mainly bedrock with large and small boulders and minor amounts of loose gravel. This site was chosen because it has a stable substrate and adequate water levels for fish passage during the smolt migration period. During the smolt run, the trap was checked and fish released on a regular 2-hour basis from 0600 hrs to 2230 hrs. Also, at each trap check several environmental parameters were measured, i.e. water temperature, air temperature, and water level. During the peak smolt run, two 30 cm openings were made in the fence on each side of the smolt trap by removing several conduit. A plywood board, light in colour, was positioned on the river bottom to count fish passing through the fence on their downstream migration. After the smolt fence was removed on June 16 th, any remaining smolts were enumerated from the adult fence until June 20th, 1998. This procedure was also followed in previous years due to the overlap of the downstream smolt with the migration of upstream adult salmon. The smolt enumeration is considered a complete count.

The adult fence was situated just below the Old Horwood Dam, approximately 212 m from

the mouth, on a bedrock substrate in a 25 m wide section of the river (Fig. 2). The fence had 16 sections (3 m long) and a 2 x 2 m adult trap, and was operated from June 12 to September 9, 1998. A tunnel with a video camera system (VHS format) was installed in the trap giving a positive overhead view of salmon moving upstream. Videotapes were reviewed the next day to count salmon and the count verified by a second viewing. If necessary, a third viewing was made to resolve any discrepancies. This system has proven to be very successful since first installed in 1993 and has allowed salmon to move upstream through the fence on a continuous basis, especially during the night when visual monitoring becomes more difficult. Use of the camera system seemed to move salmon through the fence more quickly than would have been the case with a standard fish trap. Also, during daylight hours, a 0.5 m section of the fence next to the trap was opened and monitored manually to further facilitate the upstream migration of salmon. The manual counting of salmon at the fence site from 1993-98 has accounted for 40-50% of the upstream migrating salmon passing through the fence. All salmon counted were sized into two categories, viz. small salmon less than 63 cm and large salmon 63 cm or greater. This was achieved by placing parallel marks 63 cm apart on the floor of the trap/counting device.

SEA SURVIVAL & PREVIOUS SPAWNERS

Sea survival was determined from the number of returning adults in year n+1 and the number of smolts of the preceding year n. The adult salmon counted at the fence consisted of several year classes including salmon spawning for the first time as grilse and salmon that had previously spawned. Thus, sea survival with upstream migrating previous spawners removed from small salmon counts will provide a more accurate measure of sea survival when linked with smolts from the previous year. The number of previous spawners in the returning adults was determined by mark-recapture. The proportion of migrating previous spawners tagged from 1994 to 1998, was 33.2%, 23.9%, 24.6%, 15.0% and 31.1%, respectively. Previous spawners were marked with Floy T-bar anchor tags with different colors and positions for each year. Year of tagging could then be identified by tagging position on the video screen of the counter or manually as they passed through the fence. Counts of small and large salmon were then adjusted for the number of previous spawners based on the ratio of tagged to untagged fish in the returning run and the number of outgoing kelts originally tagged. Analyses of the data from previous years indicated that these kelts would return after an average of 65 days at sea. The return rates for previous spawners from 1994 to 1998 were 25.58%, 34.85%, 39.42%, 38.96% and 33.17, respectively (Appendices 1 to 5).

ENVIRONMENTAL DATA

During field operations, environmental data were collected at both fence sites. Water temperatures were recorded by Hugrun thermograph set at 1 m from the surface at the fence site. Cloud cover, relative water levels, weather conditions and air temperatures were also recorded. Marine temperatures were obtained with a Hugrun thermograph set just off Comfort Cove in 30 meters water depth. Water temperatures have been collected here by

DFO since 1974.

EXPLOITATION RATES

Exploitation rates for the angling fishery were derived based on the number of small salmon counted at the fence and the number of salmon reported to have been caught by the angling fishery.

BIOLOGICAL CHARACTERISTICS

Biological characteristics were collected from salmon caught in the angling salmon fishery on the Campbellton River in 1992-98 by post-secondary students hired by HRDC through the Challenge Program, under the guidance of DFO technical staff. These students were responsible for collection of information on fork length, weight, sex, scales and ovaries. The biological characteristics on percentage female, mean weights, and fecundity from the sampling program were used to estimate egg depositions in 1993-98 and convert conservation requirements in eggs to spawning requirements in number of fish. Also, the percent of the conservation requirement egg deposition achieved was assessed.

Fecundity was determined from ovaries collected from the recreational fishery. Ovaries were stored in Gilson's fluid until transferred to 10% formalin. Eggs, which for the most part were in early stages of development, were counted directly. The relative fecundity value used to calculate egg deposition for both small and large salmon was 2,100 eggs per kg and was derived from mean of 78 samples taken in Campbellton River, 1993-95.

CONSERVATION REQUIREMENTS

The accessible parr-rearing habitat for Campbellton River is 5,960 units (a unit being 100 m^2) of fluvial habitat and 4037.3 ha of pond habitat (Reddin and Downton 1994). The ratio of lacustrine to fluvial habitat of 67.74 is lower than the mean of 87.11 for other SFA 4 rivers (O'Connell and Dempson 1991). Reddin and Downton (1994) derived potential smolt production for Campbellton River of 46,141 smolts by multiplying the amount of fluvial and lacustrine habitat by production parameter values of 3 smolts per unit (100 m^2) of fluvial habitat and 7 smolts per ha of lacustrine habitat (O'Connell et al. 1991).

The conservation requirements for the Campbellton River of 2,916,126 eggs was derived using egg deposition rates of 240 eggs per 100 m^2 for fluvial parr rearing habitat (Elson 1957) and 368 eggs per hectare for lacustrine habitat (O'Connell et al. 1991; Reddin and Downton 1994). Although these values may be habitat and river specific for systems from which they were derived, they are used to represent a threshold or danger zone to be avoided (O'Connell et al. 1991). Conservation requirements in eggs were converted to adult small salmon by the following formula:

(2,916,126 / (% female * mean weight * fecundity))

TOTAL RIVER RETURNS, SPAWNING ESCAPEMENT, AND EGG DEPOSITION

The egg deposition was based on the number of spawning adult female salmon and biological information collected from the angling fishery, 1992-98.

Total river returns

Total river returns (TRR) were calculated as follows:

(1) $TRR = RC_b + HRM_b + C$

where,

RC_b = angling catch below counting fence

HRM_b = hook & release mortalities below counting fence (0.1 of hook & releases)

C = count of fish at counting fence

Spawning escapement

Spawning escapement (SE) was calculated as the difference between the number of fish released from the counting fence (FR), the recreational catch retained above the fence (RC_a) and hook and release mortalities above the fence (HRM_a).

(2) $SE = FR - RC_a - HRM_a$

Egg deposition

Egg deposition (ED) was calculated separately for small and large salmon and then summed as follows:

(3) $ED = SE \times PF \times RF \times MW$

SE = number of spawners
PF = proportion of females
RF = relative fecundity (No. eggs/kg)
MW = mean weight of females

O'Connell and Dempson (1991) reported that unpublished evidence exists demonstrating that atresia (non-development of eggs) occurs to varying degrees in insular Newfoundland salmon. This phenomenon has also been reported in Atlantic salmon in the Soviet Union (Melnikova 1964) and in France (Prouzet et al. 1984). Therefore, fecundity values should be regarded as potential values. Since conservation requirements are based on eggs in early stages of development, the occurrence of atresia in a given year on a particular river would increase the number of spawners required.

ACCURACY OF EGG DEPOSITIONS

The accuracy of egg depositions is very important as it describes the status of the salmon stock in Campbellton River. Accuracy was investigated in two ways. First, by a simulation exercise which investigated the variability around several parameters and the effect of this variability on egg deposition rates. In the section on egg depositions, only the numbers of small and large salmon returning to Campbellton River in 1998 were known with certainty. To account for some of the uncertainty in other parameter values used to determine potential egg deposition, we assumed a coefficient of variation of 20% around the fecundity, percentage females and mean weight of both small and large salmon components and recalculated the estimated egg deposition using 1000 realisations from a uniform distribution.

The second way of investigating accuracy of egg deposition values was by recalculating the annual egg depositions from the biological characteristics of the upstream migrating adults sampled in the angling fishery compared to that derived from downstream migrating kelts measured at the smolt fence in the following year. The same equations are used for both estimates. If the number of samples are adequate to define biological characteristics of either group then the egg depositions from the two methods should be similar. Egg depositions from kelts are based on the number of eggs per cm whereas eggs per kg are used for the upstream migrating salmon.

SALMON POSTSMOLTS

Salmon postsmolts returning to spawn after only a couple of months at sea instead of at least a full year occur in some Newfoundland rivers. Beginning in 1995, a 35 cm mark was installed in the tunnel of the video counting chamber of the adult counting fence in Campbellton River to enable enumeration of this class of salmon. Verification of the age class of these postsmolt salmon was done by scale ageing. Data is available for 1995-98.

EFFECT OF MORATORIA

In 1992, a major change was introduced in the management of salmon in Newfoundland. A five-year moratorium was placed on the commercial fishery in insular Newfoundland while in Labrador, fishing continued under a quota until 1998 when the fishery was closed. Also, a moratorium was placed on the northern cod fishery in the northeast coast of Newfoundland. The effects of the commercial salmon fishing and cod fishing moratoria were examined

through the time series of egg depositions and resulting smolt production, sea survival rates, and conservation requirements met. Although the effects of the commercial salmon and cod moratoria cannot be separately estimated, both continued in 1998 and would have impacted on the spawning escapement beginning in 1992. The goal of the commercial salmon fishing moratorium was to increase spawning escapement while the goal of the northern cod fishery moratorium was to protect and stimulate recovery of cod stocks to previous numbers. Because salmon are caught as a bycatch in non-salmon gear, especially cod traps, the effect of the cod moratorium would be to increase spawning escapement.

The time series of data for Campbellton River is six years (1993-98) which restricts analyses that compare data from before (prior to 1992) to after (post 1991) the moratorium period. However, because smolts from Campbellton River are mainly 3^+ and 4^+ (96% on average) we can examine the smolt output of several year classes of spawners from before and after the moratoria as follows:

Category	Year class (spawners)	Smolt years
Before	1989	1993 & 1994
Before	1990	1994 & 1995
Before	1991	1995 & 1996
After	1992	1996 & 1997
After	1993	1997 & 1998
After	1994	1998 & 1999 (incomplete)

Results

ANGLING FISHERY

In 1998, the angling salmon fishery on Campbellton River recorded a catch of 565 small salmon and 8 large for a total of 573 (Table 2). Of these, 250 small and 8 large salmon were hooked and released. In 1996, 31 large fish were reported as hooked and released which is the highest value since 1975. The higher annual catches since 1992 are attributed to increases in the salmon returns as a result of the closure of the commercial fishery and also due to increased angling effort.

During the adult fence operations, the river was closed to angling 43 m above the counting fence at the Old Horwood Dam site and from below the fence to saltwater. However in years previous to the installation of the counting fence, a section of the river referred to as the "V" located at the Old Horwood Dam that received most of the fishing pressure on the lower section of the river remained open. The next site of extensive angling was centered around the lower part of Second Pond and resulted from an upgraded forestry road and new bridge which were constructed in 1992 and provided easier access to this part of the river. The

main stem between Fourth Pond and Indian Arm Pond and the lower portions of Indian Arm Brook and Neyles Brook were also popular fishing sites. Water temperatures and levels in 1998 were generally good for the first part of the angling season, which facilitated upstream migration, unlike in 1997 when in mid-July to mid-August low water levels and high water temperatures occurred.

UNRECORDED MORTALITIES

At the Campbellton River fence, visible marks were recorded on a daily basis. Overall in 1998, there were 5.63% or 207 of the 3,677 upstream migrating Atlantic salmon with visible marks. These marks were observed mainly on the head of the fish, which generally is consistent with that expected from small mesh nets, i.e. used to catch herring. Because the Campbellton counting fence is only 0.25 km from the sea, these marks had to have occurred sometime before the salmon entered freshwater. In 1994, 1995, 1996, and 1997, 6.2%, 5.0%, 4.3 % and 4.3%, respectively of the upstream migrating salmon had marks (O'Connell et al. 1996). It is concluded that there is some mortality at sea due to fishing, although the overall magnitude is unknown.

SMOLT AND ADULT SALMON COUNTS

In 1998, a total of 50,441 smolts and 351 kelts passed through the downstream fence along with several other species of fish such as smelt and brook trout (Table 3). The peak of the smolt run occurred in standard week 22 (May 28 - June 3) which accounted for 36.3% of the total migration (Table 4). Of the six years for which smolt counts are available, 1998 smolt run was the third highest in number, 6.2 % above the 1993-98 mean. The 1996 smolt run was the earliest to start and 1997 was the latest (Fig. 3). The difference in run timing for 1996 and 1997 may be attributed to spring conditions, in particular water temperature, which seem to have a direct effect on timing of smolt migration. The smolt run doubled from 31,577 in 1993 to 62,050 in 1997 and decreased by 18.1% to 50,441 in 1998. The overall mean count for 1993-98 was 47,303.

In 1998, a total of 3,275 small and 402 large salmon were counted as they passed upstream through the adult fence (Table 5). The first adult salmon was counted on 7 June and the last fish was counted on 4 September. On average, weeks 25 and 26 combined accounted for about 40% of the upstream migration, 1993-98 (Table 6). In 1998, week 25 accounted for 51% of the total run, which is the highest percent to occur in any one standard week since 1993. Large salmon returns in 1998 represented 11% of the run. Generally, the peak run for large salmon occurred after small salmon for Campbellton River from 1993-98.

In 1998, the adult counting fence was in operation from 1 June to 8 September and represents a complete upstream count for adult salmon (Table 6). However in 1996, the fence operation stopped as of August 20 due to reductions in funding. Based on small salmon counts from 1993-95, the percent entering after 20 August ranged from 0.6 to 0.8%. If the ratio after August 20 from previous years is applied to the 1996 count, then there may have been 18 to

27 small salmon entering the river after 20 August, 1996. For large salmon, the percent entering after 20 August ranged from 1.8 to 3.7% which may have resulted in 10 to 21 large salmon entering the river after 20 August, 1996. Because these numbers are only a small proportion of the total, the adult run for 1996 is considered complete.

Both smolt and adult runs at Campbellton River were considerably earlier in 1996 than in either of the other four years (Figs. 3&4). This was possibly the result of the warmer spring conditions that prevailed in 1996. Consequently, the number of adult salmon that may have entered after the 20 August may be lower than calculated from the run timing that occurred later in previous and subsequent years. Before the adult fence was removed on 20 August, the river downstream from the fence was checked visually for any adult salmon and no salmon were observed remaining in the river downstream from the fence. Therefore, it is assumed that a complete upstream migration count of adult salmon was achieved in 1996. This visual check was also done for 1998, and no salmon were seen below the fence.

SEA SURVIVAL AND PREVIOUS SPAWNERS

Smolt-to-adult survival for the 1997 smolt class from Campbellton River (SFA 4) was 5.28% (Table 7, Fig. 5). Estimates of smolt-to-adult survival were 9.05%, 7.28%, 8.08% and 3.38%, respectively for the 1993, 1994, 1995 and 1996 smolt classes. Calculations to derive these values are summarized in Appendices 1 to 5. These values are overestimates of survival from smolt to 1SW (grilse) salmon because some of the small salmon migrating upstream are in fact previous spawners that survived from grilse that migrated upstream in previous years. Kelts tagged passing through the downstream smolt fence allowed for correction of the number of previous spawners in the upstream run and calculation of sea survival rates for 1SW salmon excluding previous spawners. The results of the tagging study indicated that 33.4% of the small salmon returning to Campbellton River in 1997 were previous spawners (Appendix 4). For the 1997 smolt class, the corrected survival rates after removal of previous spawners is 2.25%, which is the lowest percent during the fence operation from 1993-98 (Table 7). Average sea survival for salmon returning to Campbellton River was 5.7%, 1993-98. Over-wintering survival of salmon spawning in Campbellton River has averaged about 70.6% from 1994-98. Due to the late installation of the counting fence in 1998, many kelts had probably already migrated out of the system and were not included in the count. Thus, survival rates had to be derived from average of rates of previous years. The proportion of the adult run consisting of previous spawners is estimated to be 13.1% (Appendix 5).

ENVIRONMENTAL DATA

Water temperatures for 1998 ranged from a low of 1.1 C on April 16 to a peak of about 26.2 C on August 12 (Fig. 5). Maximum and minimum air temperatures were 32.7 and 6.7 C during the angling recreational season. Both water temperatures and levels stayed within an appropriate range for salmon during May to mid-June and August; however during mid-June to the end of July conditions were not as favorable to upstream migrations in 1998 as in some

other years (Fig. 5). Unfavourable freshwater conditions (low water levels and high water temperatures) which are becoming more and more common during summer months in Newfoundland can act as a barrier to salmon migration. During these periods, some salmon will remain in the estuary only ascending the river after sufficient rainfall has ameliorated freshwater conditions.

EXPLOITATION RATES

In 1998, a total of 3,275 small salmon passed through the counting fence and there was a catch of 315 small and large salmon retained by the angling fishery above the fence. There were no salmon caught in the river below the fence. The exploitation rate in 1998 was 9.6% for small retained salmon (95% CI=8.6%, 10.7%). Overall exploitation has been increasing on Campbellton River, 1993-98. Exploitation on small salmon (retained only) has almost doubled between 1993 and 1998 when compared to past years, the exception being in 1997 when the fishery was closed due to low returns. In 1998, the exploitation rate for small released salmon was the highest since 1993, at 250 fish. Exploitation on the total population has increased by about 50% from 1993 to 1996. Rod days have increased from 1,355 in 1993 to 1,964 in 1996. Exploitation rates are shown in the following text table:

Year	Small retained	Small ret. + rel.	Large released	Total
1993	7.9%	10.5%	0.0%	10.1%
1994	11.9%	12.0%	0.5%	11.3%
1995	12.9%	14.5%	0.5%	13.6%
1996	14.4%	17.3%	5.5%	15.6%
1997	12.1%	15.2%	2.2%	13.4%
1998	9.6%	17.3%	2.0%	15.6%

BIOLOGICAL CHARACTERISTICS

The river ages of smolts sampled at the counting fence 1993-98 ranged from 2 to 6 years with the 3 river years being predominant (Table 8a). The number of river age 3 smolts increased from 1993 to 1997 and then declined in 1998. More important the percent of river age 3 smolts increased from 1993 to 1995 and then declined in 1998 when river age 4 smolt

became dominant increasing to slightly over 50% of the run.

Approximately 0.5% of the smolt migration was sampled each year 1993-98, which represents a total of approximately 1,400 fish. The mean whole weight of 49.1 g was slightly higher for female smolt than the 47.6 g for males (Table 8b). The overall mean fork length and whole weight was 173 mm and 48.7 g, respectively. Overall mean river age was 3.5 years.

From 1992 to 1998, 254 adult salmon were sampled from the recreational fishery and a further 51 salmon were sampled at the counting fence for a total of 305 (Tables 9 & 10). Overall mean fork length of the grilse was 52.9 cm with a mean whole weight of 1.54 kg and 3.23 river age (Tables 8). Twenty-five (10%) of the small salmon that were sampled during 1992-98 had previously spawned. Also, three fish were sampled that returned to freshwater in the same summer that they went to sea as smolts. River age of salmon sampled in the angling fishery and at the counting fence show a very high percentage of river age 3 salmon and a much lower percentage of river age 4 than the smolt sampling (Table 10). The reasons for these differences are unclear but may be related to differential survival and in some years low sample sizes from the angling fishery.

The biological characteristics of salmon sampled in the recreational fishery and at the counting fence are used to annually determine the number of eggs deposited in the system by female spawners and the percent of the conservation requirement met. The percentage of female salmon sampled from the recreational fishery in 1992-98 was 77% (Table 11). The mean weight for small female salmon was 1.51 kg (n=170 and sd=0.27). Because of low sample sizes in 1998 of 27 small and 22 large salmon, the average percent female and whole weight, 1993-98 were used to calculate the percent of the conservation requirement met. There were no samples for large salmon available from Campbellton River due to the mandatory release of large salmon in the recreational fishery introduced in 1984. Default values for mean weight and the percentage of large salmon that are female are 3.13 kg and 76.9%. These default values were derived from several rivers in SFA 4 (O'Connell et al. 1996).

CONSERVATION REQUIREMENTS AND POTENTIAL SMOLT PRODUCTION

The estimated conservation requirements for Campbellton River in terms of eggs as well as adult salmon were estimated as follows:

	Lacustrine	Fluvial	Total
Accessible habitat	4037.3 ha	5,960 units	-
Eggs (No. x 10^6)	1.486	1.430	2,916,126

Conservation requirements converted to numbers of small salmon (Reddin and Downton

1994):

$$= \frac{2{,}916{,}126 \text{ eggs}}{(\% \text{ female} * \text{mean wt} * \text{fecundity})}$$

$$= \frac{2{,}916{,}126}{(0.774 * 1.51 * 2100)}$$

= **~ 1480 small salmon**

Estimated potential smolt production are as follows:

Fluvial smolt	= 3 smolts/unit * 5960 units	= 17,880
Lacustrine smolt	= 7 smolts/ha * 4,037.3 ha	= 28,261
Total potential smolt production		= 46,141

TOTAL RIVER RETURNS, SPAWNING ESCAPEMENT, AND EGG DEPOSITION

Total river returns

In 1998, there were 3,275 small and 402 large salmon returning to Campbellton River (Table 12).

Spawning escapement

In 1998, there were 2,935 small and 401 large salmon potentially spawning in Campbellton River (Table 12).

Egg deposition

In 1998, egg deposition on Campbellton River was $9.231 * 10^6$. Thus, 317% of conservation requirements in eggs were achieved in 1998, an increase of almost 60% from 1997, and 15% higher than the potential egg deposition obtained over the previous five years (1993-97). Tables 12 and 13a summarise updated information on egg deposition at Campbellton River for all years in which fish counting fences have been operated.

Freshwater survival from eggs to smolt is available for the 1993 year class. Freshwater survival was estimated by dividing the egg deposition of $9.077 * 10^6$ in 1993 into the smolt count of 2 year olds in 1996, 3 year olds in 1997, and 4 year olds in 1998. Freshwater survival was 0.68%.

ACCURACY OF EGG DEPOSITION ESTIMATES

In determining egg deposition in the previous section, only the numbers of small and large

salmon returning to Campbellton River in 1998 were known with certainty. Campbellton River would have attained its conservation egg requirements at all egg deposition levels in 1998 (Fig. 7). At the 50th percentile, 8,071,714 eggs were deposited which represents 277% of conservation requirement of 2,916,126 eggs based on this level of variation. The corresponding 5th and 95th percentiles of the percentage of conservation requirement met varied from 240 to 318%.

The precision of annual egg deposition values was examined by deriving egg depositions from the biological characteristics of the upstream migrating adults sampled in the angling fishery compared to that derived from downstream migrating kelts measured at the smolt fence in the following year. Comparison of values derived on fresh run versus kelts shows 311% versus 304% in 1993, 239% versus 220% in 1994, 279% versus 256% in 1995, 304% versus 256% in 1996, and 200% versus 185% in 1997 (Table 13 a & b). Because the percentage of conservation requirements achieved is always slightly higher when based on fresh run salmon suggests there may be a tendency to overestimate rather than underestimate the percent of conservation requirements achieved. However, the similarity of the two values suggests that the tendency to overestimate is small.

SALMON POSTSMOLTS RETURNING TO FRESHWATER

Stocks of Atlantic salmon exhibit various life history patterns including several alternate strategies. The entire life cycle can take place in freshwater; they can start life in the river, then migrate between river and estuary; they can migrate between river and estuary and then go to sea; or they can have the more typical anadromous life cycle of going to sea for one or more years before returning to freshwater (Power et al. 1987). In Newfoundland and Labrador, salmon migrate to sea at two to seven years of age then returning to freshwater after spending at least one or more years in the sea. Salmon that have spawned one or more times after one or more years in the sea are also quite common. As evidenced by scale reading of a few salmon sampled that were caught by anglers or at enumeration facilities, a small minority of salmon exists that spend only a couple of months at sea before returning to freshwater. Because they do not spend a full year at sea, these salmon are typically very small being less than 40 cm fork length. Also, as they are uncommon the salmon nomenclature does not have a separate name for this life stage and they would be labelled as post-smolts (Allan and Ritter 1977). However, in the context of this report, they are referred to as precocious post-smolts.

In 1995, anglers observed for a number of rivers, e.g. Southwest Brook in Bay St. George, a high number of very small salmon migrating upstream. In 1993 and 1994, a few very small (<40 cm) salmon were observed at the counting fence ascending Campbellton River. In the spring of 1994, several of these small salmon were sampled as kelts descending through the smolt counting fence. In total, out of 907 kelts sampled there were four or 0.4% that had not completed a full year in the sea. Another 12 or 1.4% of the kelts had no complete sea year but showed 2 or more spawning marks. Overall, the proportion of the run that could be labelled as postsmolts remains a relatively minor component of the run.

In 1995, 13 salmon of approximately 28-35 cm in length were observed ascending through the Campbellton River counting fence. The total upstream run was 13 postsmolts, 3,035 small and 218 large salmon; thus, the upstream run consisted of 0.4% postsmolts. In 1998, the number of small salmon less than 35 cm was 51 fish and represented 1.6% of the small salmon at the counting fence. Four of these small fish were sampled at the adult fence and all indicated incomplete sea year before returning to the river to spawn (precocious post smolts).

EFFECTS OF MORATORIA

The smolt counts and the age information from the smolts as shown in Table 8a was organized as follows:

Category	Year class (spawners)	Number of smolts		
Before	1989	15,710 & 12,620	=	28,330
Before	1990	25,931 & 13,805	=	39,736
Before	1991	24,774 & 20,050	=	44,824
After	1992	34,975 & 24,547	=	59,522
After	1993	35,685 & 25,326	=	61,011
After	1994	22,946 & not available until 1999		

The pre-moratoria year classes of 1989-91 produced on average 37,630 smolts; while from post-moratoria year classes of 1992-93 produced on average 60,267 smolts. The difference between pre- and post-moratoria smolt production is 22,637 for an increase of 60%. This sixty percent increase in smolt production may have come about due to an increase in spawning escapement due to the moratoria or were possibly due to productivity increases in freshwater. For Campbellton River, the spawning escapement prior to 1993 is unknown. It should be noted that 3^+ smolts in 1997 which also come from post moratoria spawning escapements has declined to 22,946 which is similar to smolt production of 3^+ from before the moratoria. Adult returns of small salmon from the 1993-95 smolt classes ranged from 2,857 to 3,208 with an average of 3,033 while adult returns from 1996-97 smolt classes were 1,975 and 3,275, an average of 2,625. Thus, returns have actually declined by 408 fish or 13% for smolt classes from pre- and post-moratoria. This decline in adult returns occurred in spite of increased smolt production and seems to be directly related to sea survival which has gone from an average of 6.8% for the 1993-95 smolt classes to 3.6% for the 1996-97 smolt classes. The percent of conservation requirements met for Campbellton River from 1993 to 1998 ranged from 200% to 317% assuming that all fish minus those dead from angling spawned (Table 12). Thus, the high number of adult returns is being maintained by the high smolt production and benefits from the moratoria on commercial fishing have not yet followed through to adult returns.

Discussion

Taylor (1985) discussed the historical catch record for many rivers in Newfoundland and Labrador. He states that the relatively high Atlantic salmon abundance in the Campbellton River made it valuable to the Beothucks and Europeans alike. The earliest catch record specific to Campbellton River indicates that a John Ginn landed 90 tierces of salmon on or about the year 1816. Because the early European settlers fished by placing a weir across the entire river and because there was no coastal gillnet fishery, these catches are an approximation of total salmon production of Campbellton River when it was in a pristine state. The 90 tierces converts to 18,400 kg using the conversion factors of Taylor (1985). This weight of fish converts to about 12,000 salmon if the mean weights of 1993-96 period are used. The highest count in the 1993-98 period is 4,146 or about 30% of that which Campbellton River may have produced when it was in a more natural state prior to heavy exploitation in commercial marine fisheries.

At the conservation requirement of 1,480 spawners, it is expected that about 48,000 smolts would be produced by Campbellton River. At an average sea survival rate and proportion large salmon, 48,000 smolts could produce about 4,600 adult salmon. If Campbellton River still has similar freshwater habitat to that present in 1816 then perhaps the difference between the 4,600 adult salmon produced at conservation requirements and the 12,000 it produced in a more virgin state is it's maximum production. Since the percent of the conservation requirement achieved on average for Campbellton, 1993-98 is about 275% it would be interesting and potentially very informative to be able to monitor adult returns in 1999-2001. Alternately, since there is a value for only one year, the presumed historic production of 12,000 salmon may have represented an extreme maximum value.

For Campbellton River, there was no detailed habitat survey available (Porter et al. 1974). Thus, the habitat values given in this paper should be regarded as preliminary and will be subject to further review. The Campbellton River watershed has had extensive logging activity in the past. Especially in the early 1900's when a 400 m long, 10 m high dam was erected by the Horwood Lumber Company near the mouth of the river to divert water into a 350 m rock-cut channel to run a pulp mill and hydro plant. At this time, the Horwood Lumber Co. had timber rights to 596 km^2 and used the river as a means to float logs to the mill. However, this operation was short lived since the dam broke in 1916 and the company went into bankruptcy. Extensive logging continued in and around the Campbellton River watershed up to 1966 when 22 small dams were removed by Price (Nfld) Ltd. under the supervision of the Department of Fisheries and Oceans. The structures from these historical logging activities are still visible in the remains of dams and tree trunks scattered at various points along the river. The remains of several dams located on the Crooked Brook tributary, which empties into Second Pond, still pose a partial obstruction to migrating salmon during low water levels. In 1961, the upper watershed near Shirley Lake and Silt Lake was completely destroyed by fire, which only now has returned to normal forest growth. Although the river is no longer used to drive logs to the sea, logging still continues over the

network of roads built specifically for that purpose. The overall effects of these logging activities on the production of salmon in the system are unknown.

Since the habitat in Campbellton River has not been completely surveyed the conservation requirement may be an over- or under-estimate. The total number of adult salmon spawning in 1998 resulted in an egg deposition that was 317% over conservation requirements. It was noted during the helicopter survey that many of the spawning areas on the main stem were located between relatively small and shallow ponds. These shallow ponds may provide for an optimal utilization of rearing habitat and a higher rearing capacity may result. Therefore, caution must be used when referring to conservation requirements until a full habitat survey is completed.

For Campbellton River, the smolt production of 50,441 for 1998 is 109% above the calculated potential smolt production of 46,141. The modal smolt age for Campbellton River salmon is 4 years and thus, the 1998 smolt run is derived mainly from adults that spawned in the fall of 1994. For most Newfoundland rivers, spawning escapements in 1997 were the lowest on record in the period 1989-91 (Dempson and O'Connell 1993). Escapements on northeast coast Newfoundland rivers increased in 1992 with the beginning of the commercial salmon fishing moratorium. Consequently, smolt production stemming from spawning escapements in the post-moratorium years may be much closer to this potential figure. Although salmon returns to Campbellton River may be the second highest since 1993, the survival rate of smolt to adult is considered low at 4.94% when compared to rate prior to 1997.

Assumptions associated with the parameter values used to calculate the conservation spawning requirement have been discussed previously by O'Connell et al. (1991), O'Connell and Dempson (1991), O'Connell and Ash (1994) and will not be dealt with in detail here. The comments in O'Connell and Ash (1994) on further substantiation of parameter values for calculations related to egg deposition apply as well to Campbellton River. Also, it should be kept in mind that inaccuracies in catch statistics, losses to due poaching, losses due to hook and release mortality, and losses from natural mortality will potentially reduce spawning escapement.

In conclusion, due to the maintenance of strong adult returns in 1993-98, the percent of conservation requirements being met on Campbellton River remains high in spite of lower than average sea survival in the last two years. Benefits of increased spawners released from commercial fisheries due to commercial fisheries moratoria, have not been fully realized; although increased smolt production has maintained strong adult returns.

Acknowledgments

The project was funded by a grant from Human Resources Development Canada, under the Job Creation Program to the Lewisporte Area Development Association (LADA). The

assistance of the following persons is gratefully acknowledged: DFO Resource Management Branch, Twillingate, the field staff provided by LADA, and Mr. R. Johnson, DFO Science Branch.

References

Allan I.R.H. & Ritter J.A. 1977. Salmonid terminology. Journal du Cons., Cons. Int. Explor. Mer, 37:293-299.

Anderson, T. C. and B. P. McDonald. 1978. A portable weir for counting migrating fishes in rivers. Fish. Mar. Serv. Tech. Rep. 733: 13 p.

Ash, E. G. M., and M. F. O'Connell. 1987. Atlantic salmon fishery in Newfoundland and Labrador, commercial and recreational, 1985. Can. Data Rep. Fish. Aquat. Sci. 672: v + 284 p.

Brobbel, M.A., M.P. Wilkie, J.D. Kieffer, and B.L. Tufts. 1996. Physiology effects of catch and release angling in Atlantic salmon (*Salmo salar*) at different stages of freshwater migration. Can. J. Fish. Aquat. Sci. 53: 2036-2043.

Dempson, J. B. and M. F. O'Connell. 1993. Impacts of the 1992 Atlantic salmon (*Salmo salar* L.) commercial fishery moratorium - Newfoundland Region. DFO Atl. Fish. Res. Doc. 93/11. 28 p.

Elson, P. F. 1957. Using hatchery reared Atlantic salmon to best advantage. Can. Fish. Cult. 21: 7-17.

Melnikova, M. N. 1964. The fecundity of Atlantic salmon (***Salmo salar*** L.) from the Varguza River. Vopr. Ikhtiol. 4: 469-476.

Porter, T. R., L. G. Riche, and G. R. Traverse. 1974. Catalogue of rivers in insular Newfoundland. Volume D. Resource Development Branch, Newfoundland Region, Department of Environment, Fisheries and Marine Service Data Record Series No. NEW/D-74-9: 316 pp.

O'Connell, M. F. and J. B. Dempson. 1991. Atlantic salmon (***Salmo salar*** L.) target spawning requirements for rivers in Notre Dame Bay (SFA 4), St. Mary's Bay (SFA 9), and Placentia Bay (SFA 10), Newfoundland. CAFSAC Res. Doc. 91/18, 14 p.

O'Connell, M. F., J. B. Dempson, and R. J. Gibson. 1991. Atlantic salmon (***Salmo salar*** L.) smolt production parameter values for fluvial and lacustrine habitats in insular Newfoundland. CAFSAC Res. Doc. 91/19, 11 p.

O'Connell, M. F. and E. G. M. Ash. 1994. Status of Atlantic salmon (***Salmo salar*** **L.**) in Gander River, Notre Dame Bay (SFA 4), Newfoundland, 1993. DFO Atl. Fish. Res. Doc. 94/50. 17 p.

O'Connell, M. F., C. C. Mullins, & D. G. Reddin. 1996. Status of Atlantic salmon (*Salmo salar L.*) in eight rivers in the Newfoundland Region, 1995. DFO Atlantic Fisheries Research Document 96/106, 52 p.

O'Connell, M. F., N. M. Cochrane, and C. C. Mullins. 1998. An analysis of the License Stub Return System in the Newfoundland Region, 1994-97. DFO Can. Stock Assess. Sec. Research Document 98/111, 67 p.

Power, G., M.V. Power, R. Dumas, and A. Gordon. 1987. Marine migrations of Atlantic salmon from rivers in Ungava Bay, Quebec. American Fisheries Society Symposium 1:364-376.

Prouzet, P., Y. LeBail, and M. Heydorff. 1984. Sex ratio and potential fecundity of Atlantic salmon (***Salmo salar*** **L.**) caught by anglers on the Elorn River (Northern Brittany, France) during 1979 and 1980. Fish. Mgmt. 15: 123-130.

Reddin, D. G. and P. R. Downton. 1994. Status of Atlantic salmon (*Salmo salar L.)* in Campbellton River, Notre Dame Bay (SFA 4), Newfoundland in 1993. DFO Atlantic Fisheries Res. Doc. 94/86. 28 p.

Riche, L. G. 1972. An outline of methods used in stream surveys and estimation of salmon production with a suggested value for Atlantic salmon sports fish in Newfoundland. Fish. Serv. Res. Dev. Branch Nfld. Region Prog. Rep. 81: iii + 23p.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Fish. Res. Bd. Canada Bull. 191. 382 pp.

Ricker, W.E. 1976. Review of the rate of growth and mortality of Pacific salmon in salt water and non catch mortality caused by fishing. J. Fish. Res. Bd. Canada 33: 1483-1524.

Taylor, V. R. 1985. The early Atlantic salmon fishery in Newfoundland and Labrador. Can. Spec. Publ. Fish. Aquat. Sci. 76: 71 p.

Table 1 . The total rod days, total catch and catch per unit effort (CPUE) for both small and large Atlantic salmon retained in the recreational fishery for Insular Newfoundland ,Salmon Fishing Area 4 and the Campbellton River from 1953 to 1998.

	Rod days			Total catch (ret. + rel.)			CPUE		
Year	Insular NFLD	SFA 4	Campbellton River	Insular Newfoundland	SFA 4	Campbellton River	Insular Newfoundland	SFA 4	Campbellton River
1953	43,024	8,630	346	16,025	3,485	126	0.37	0.40	0.36
1954	28,505	7,344	587	8,705	1,600	102	0.31	0.22	0.17
1955	21,974	5,125	56	11,128	2,616	61	0.51	0.51	1.09
1956	53,092	10,672	341	16,702	4,350	119	0.31	0.41	0.35
1957	33,211	8,789	291	20,458	4,950	105	0.62	0.56	0.36
1958	34,444	5,888	592	20,844	5,001	447	0.61	0.85	0.75
1959	36,277	6,321	325	18,368	4,220	303	0.51	0.67	0.93
1960	35,750	7,051	313	17,336	3,950	265	0.48	0.56	0.85
1961	36,024	5,277	209	15,634	2,280	146	0.43	0.43	0.70
1962	49,035	8,842	397	24,808	4,879	147	0.51	0.55	0.37
1963	60,789	10,910	1,242	31,292	4,042	421	0.51	0.37	0.34
1964	71,541	15,608	1,066	39,276	7,917	496	0.55	0.51	0.47
1965	66,647	13,749	647	31,975	4,551	468	0.48	0.33	0.72
1966	66,414	15,249	881	30,605	6,627	689	0.46	0.43	0.78
1967	72,577	13,915	815	25,081	4,226	487	0.35	0.30	0.60
1968	75,575	15,318	1,577	31,303	6,139	743	0.41	0.40	0.47
1969	82,046	13,807	992	37,275	4,138	534	0.45	0.30	0.54
1970	84,912	15,759	660	32,592	4,896	437	0.38	0.31	0.66
1971	75,788	11,379	622	28,291	3,841	299	0.37	0.34	0.48
1972	69,219	10,778	452	25,804	3,468	210	0.37	0.32	0.46
1973	88,435	14,544	1,344	37,435	5,759	971	0.42	0.46	0.72
1974	108,199	22,038	1,956	27,698	5,455	505	0.26	0.25	0.26
1975	102,907	22,384	1,768	34,631	6,109	487	0.34	0.27	0.28
1976	115,847	24,787	2,042	35,514	6,871	834	0.31	0.28	0.41
1977	111,836	28,117	2,134	37,107	9,482	912	0.33	0.34	0.43
1978	96,659	24,131	1,314	30,182	9,276	429	0.31	0.38	0.33
1979	82,578	21,496	53	31,730	8,353	23	0.38	0.39	0.43
1980	104,332	25,172	2,293	37,771	9,921	1,112	0.36	0.39	0.48
1981	122,476	32,282	2,950	48,039	13,897	1,549	0.39	0.43	0.53
1982	129,369	32,929	1,674	43,119	10,231	473	0.33	0.31	0.28
1983	126,308	26,649	1,819	33,802	9,251	597	0.27	0.35	0.37
1984	121,979	29,633	2,657	39,842	9,915	992	0.33	0.33	0.37
1985	120,030	34,329	3,219	36,867	12,190	782	0.31	0.36	0.24
1986	123,528	31,850	1,791	38,294	9,293	422	0.31	0.29	0.24
1987	85,969	18,564	803	24,892	5,453	169	0.29	0.29	0.21
1988	120,497	27,413	1,837	40,441	9,854	636	0.34	0.36	0.35
1989	91,286	17,767	854	18,645	3,786	148	0.20	0.21	0.17
1990	105,736	23,533	693	30,470	5,661	106	0.29	0.24	0.15
1991	89,812	21,999	693	20,865	4,892	126	0.23	0.22	0.18
1992	95,931	19,485	916	30,173	6,810	341	0.31	0.35	0.37
1993	125,661	30,598	1,355	42,736	13,114	419	0.34	0.43	0.31
1994	141,508	43,242	1,484	39,381	12,158	345	0.28	0.28	0.23
1995	143,275	36,717	1,775	40,818	11,329	441	0.28	0.31	0.25
1996		44,385	1,964	57,957	17,566	587		0.40	0.30
1997 *				36,176	6,152	330			
1998 **				33,735	10,441	573			
Mean (53-98)	84,907	19,642	1,173	30,692	6,987	455			
Mean percent of Island		23.1%	1.4%		22.8%	1.5%			
Campbellton River to mean percent of SFA 4			5.97%			6.51%			

* Note: recreation fishing was closed on July 28 for SFA 4 therefore effort is only a partial figure
** data not completed for 98

Table 2a. Atlantic salmon recreational statistics for Campbellton River, Notre Dame Bay, SFA 4, 1974-98.

River: Campbellton River River code: 0708210

	Effort	Small (<63 cm)			Large (>=63 cm)			Total (Small + Large)			
Year	Rod Days	Ret.	Rel.	Tot.	Ret.	Rel.	Tot.	Ret.	Rel.	Tot.	CPUE
1974	1956	505	.	505	0	.	0	505	.	505	0.26
1975	1768	424	.	424	63	.	63	487	.	487	0.28
1976	2042	834	.	834	0	.	0	834	.	834	0.41
1977	2134	895	.	895	17	.	17	912	.	912	0.43
1978	1314	426	.	426	3	.	3	429	.	429	0.33
1979	53	23	.	23	0	.	0	23	.	23	0.43
1980	2298	1112	.	1112	0	.	0	1112	.	1112	0.48
1981	2950	1547	.	1547	2	.	2	1549	.	1549	0.53
1982	1674	471	.	471	2	.	2	473	.	473	0.28
1983	1619	597	.	597	0	.	0	597	.	597	0.37
1984	2657	991	.	991	1	.	1	992	.	992	0.37
1985	3219	782	.	782	*	.	0	782	.	782	0.24
1986	1791	422	.	422	*	.	0	422	.	422	0.24
1987	803	169	.	169	*	.	0	169	.	169	0.21
1988	1837	636	.	636	*	.	0	636	.	636	0.35
1989	854	148	.	148	*	.	0	148	.	148	0.17
1990	693	106	.	106	*	.	0	106	.	106	0.15
1991	693	126	.	126	*	.	0	126	.	126	0.18
1992	916	311	30	341	*	0	0	311	30	341	0.37
1993	1355	316	103	419	*	0	0	316	103	419	0.31
1994	1484	340	4	344	*	1	1	340	5	345	0.23
1995	1775	393	47	440	*	1	1	393	48	441	0.25
1996	1964	463	93	556	*	31	31	463	124	587	0.30
1997**		254	67	321	*	9	9	254	76	330	
1998**		315	250	565	*	8	8	315	258	573	
84-89 $\bar{X}$	2071.6	595.8	.	595.8	.	.	.	596.0	.	596.0	0.29
95% CL	1123.4	403.8	.	403.8	.	.	.	404.2	.	404.2	0.10
N	5	5	0	5	0	0	0	5	0	5	5
86-91 $\bar{X}$	1173.6	287.6	.	287.6	.	.	.	287.6	.	287.6	0.25
95% CL	730.6	289.8	.	289.8	.	.	.	289.8	.	289.8	0.11
N	5	5	0	5	0	0	0	5	0	5	5
92-96 $\bar{X}$	1498.8	364.6	55.4	420.0	.	6.6	6.6	364.6	62.0	426.6	0.28
95% CL	501.7	79.3	52.1	109.1	.	16.9	16.9	79.3	62.1	124.1	0.06
N	5	5	5	5	0	5	5	5	5	5	5

1987 DATA NOT INCLUDED IN MEAN

IN THE ABOVE TABLE A PERIOD INDICATES NO DATA FOR THAT YEAR

CPUE IS BASED ON RETAINED + RELEASED FISH FOR 1992 - 1996 AND ON RETAINED FISH ONLY PRIOR TO 1992

* NOT ALLOWED TO RETAIN LARGE SALMON IN INSULAR NEWFOUNDLAND

** DATA DERIVED FROM THE RECREATIONAL LICENCE STUB RETURN (1998 DATA IS PELIMINARY)

Table 2b. Number of fishers, gear units and catches of Atlantic salmon in the commercial fishery for SFA 4 and Insular Newfoundland and means for 1984-90 compared to 1991.

	Salmon fishing Area 4						Insular Newfoundland					
Year	Number of commercial fisherman	Gear units (91.5 m)	Catch (metric tons) Small	Catch (metric tons) Large	Catch (numbers) Small	Catch (numbers) Large	Number of commercial fisherman	Gear units (91.5 m)	Catch (metric tons) Small	Catch (metric tons) Large	Catch (numbers) Small	Catch (numbers) Large
1984	892	3,124	73	50	38,857	10,976	3,065	11,008	241	240	130,131	54,283
1985	695	2,768	68	43	37,957	10,019	2,480	9,878	348	242	191,216	57,537
1986	696	2,782	119	81	59,902	17,047	2,480	9,916	392	282	200,267	60,699
1987	693	2,764	109	71	54,935	15,087	2,480	9,784	434	357	225,025	77,945
1988	682	2,728	68	35	36,016	8,179	2,380	9,520	249	191	134,562	43,581
1989	679	2,716	85	48	46,988	10,834	2,360	9,440	266	190	148,297	46,261
1990	669	2,674	62	31	32,648	6,940	2,320	9,270	171	180	92,554	39,497
Means (84-90)	**715**	**2,794**	**83**	**51**	**43,900**	**11,297**	**2,509**	**9,831**	**300**	**240**	**160,293**	**54,258**
1991	**647**	**2,588**	**30**	**27**	**15,609**	**6,301**	**2,240**	**8,992**	**136**	**130**	**74,202**	**32,604**
% drop in 1991 fishing, compared to 1984 to 1990 means	**9.53%**	**7.36%**	**64.04%**	**47.35%**	**64.44%**	**44.23%**	**10.73%**	**8.53%**	**54.69%**	**45.90%**	**53.71%**	**39.91%**

Note : In 1990 and 1991 a quota system was in placed and accounted for earily clousres for several SFA 's, during their fishing season, although set quota levels were not reached for SFA 4 and Insular Newfoundland for both years. Therefore slightly higher catches may have resulted in Insular Newfoundland.

Table 3. Daily count of downstream migrating fish at Campbellton River through the counting fence in 1998.

Date	Parr	Smolt	Precocious Post smolt	Kelt	Ouananiche	Brook trout	Smelt	Eel
13-May	2	5		2				
14-May	10	149		22		5		
15-May	27	801	2	23	1	20	4	
16-May	23	566	1	17		12	11	
17-May	10	378	1	12		14	9	
18-May	13	270	3	7		18	7	
19-May	30	150	1	7		6	16	
20-May	29	453	4	6		9	18	
21-May	40	1462	12	14		12	21	
22-May	37	3286	3	16		34	13	
23-May	15	2360	4	9		31	7	1
24-May	29	2544	4	20	2	53	8	1
25-May	24	1934	3	19	1	42	17	
26-May	7	970		12		36	6	
27-May	6	2187	1	6	9	18	20	
28-May	13	2552	5	7	16	23	7	
29-May	7	2665	3	23	7	15	14	
30-May	5	2126	3	8		13	6	
31-May	8	3736		12		11	11	
01-Jun	3	2974	1	7		13	11	
02-Jun	8	2002	1	24	1	8	8	
03-Jun	8	2267	1	12		5	15	
04-Jun	12	2434	5	6		10	12	
05-Jun	2	2871	2	8		16	13	
06-Jun	4	2143	2	6		6	9	
07-Jun	2	1063		4		10	12	
08-Jun	1	479		5		2	12	
09-Jun		371		2			12	
10-Jun	1	596	1	3		1	22	
11-Jun	6	397		2		1	7	
12-Jun	4	1204	1	12		4	29	
13-Jun	5	1110	2	8		1	26	
14-Jun	13	691	1	5		2	20	
15-Jun	4	455		3			26	
16-Jun	8	220	1	1		1	31	3
17-Jun		125						
18-Jun	2	289	1	1				
19-Jun		141						1
20-Jun		15						
Total	418	50,441	69	351*	37	452	460	6

* This figure may be incomplete due to the late installation of the counting fence

Table 4. Number and percent of smolt migrating downstream by standard week through the counting fence on the Campbellton River, 1993-98.

Dates		Standard week	1993		1994		1995		1996		1997		1998		Mean	
			Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
April	23-29	17							44	0.08					8	0.02
May	30-06	18			1	0.00			2,146	3.68					358	0.76
	07-13	19			16	0.04	3	0.01	3,152	5.40			0	0.00	529	1.12
	14-20	20	125	0.40	224	0.54	15	0.04	14,833	25.41	20	0.03	2,772	5.50	2,998	6.34
	21-27	21	6,607	20.92	2,137	5.13	826	2.08	14,243	24.40	90	0.15	14,743	29.25	6,441	13.62
	28-03	22	7,071	22.39	7,842	18.82	8,228	20.72	13,358	22.89	2491	4.01	18,322	36.32	9,552	20.19
June	04-10	23	9,915	31.40	17,297	41.52	14,409	36.28	8,264	14.16	14017	22.59	9,957	19.74	12,310	26.02
	11-17	24	4,518	14.31	12,091	29.02	11,566	29.12	2,156	3.69	28641	46.16	4,202	8.33	10,529	22.26
	18-24	25	3,012	9.54	1,876	4.50	4,020	10.12	121	0.21	14908	24.03	445	0.88	4,064	8.59
	25-01	26	253	0.80	147	0.35	495	1.25	52	0.09	1883	3.03			472	1.00
July	02-0	27	76	0.24	32	0.08	98	0.25							34	0.07
	09-15	28	0	0.00	0	0.00	55	0.14							9	0.02
Total			31,577		41,663		39,715		58,369		62,050		50,441		47,303	
Start date for fence			14-May		05-May		08-May		24-Apr		18-May		13-May			
End date for fence			10-Jul		12-Jul		15-Jul		30-Jun		01-Jul		20-Jun			

Table 5. The upsteam migration of Atlantic salmon adults through the counting fence on Campbellton River , 1998.

Date	Small	Large	Total
01-Jun	0	0	0
02-Jun	0	0	0
03-Jun	0	0	0
04-Jun	0	0	0
05-Jun	0	0	0
06-Jun	0	0	0
07-Jun	4	1	5
08-Jun	10	4	14
09-Jun	10	2	12
10-Jun	3	0	3
11-Jun	13	9	22
12-Jun	11	2	13
13-Jun	6	2	8
14-Jun	9	3	12
15-Jun	31	2	33
16-Jun	24	4	28
17-Jun	62	11	73
18-Jun	194	6	200
19-Jun	257	11	268
20-Jun	341	11	352
21-Jun	457	9	466
22-Jun	294	11	305
23-Jun	115	5	120
24-Jun	155	6	161
25-Jun	90	0	90
26-Jun	82	3	85
27-Jun	135	11	146
28-Jun	83	6	89
29-Jun	65	5	70
30-Jun	38	1	39
01-Jul	32	1	33
02-Jul	70	5	75
03-Jul	14	1	15
04-Jul	7	2	9
05-Jul	7	2	9
06-Jul	48	25	73
07-Jul	41	10	51
08-Jul	12	1	13
09-Jul	33	23	56
10-Jul	168	107	275
11-Jul	41	12	53
12-Jul	1	0	1
13-Jul	8	2	10
14-Jul	6	1	7
15-Jul	9	1	10
16-Jul	7	5	12
17-Jul	1	1	2
18-Jul	36	5	41
19-Jul	15	2	17
20-Jul	6	2	8

Table 5. continued

21-Jul	13	11	24
22-Jul	8	4	12
23-Jul	10	2	12
24-Jul	15	6	21
25-Jul	28	15	43
26-Jul	28	3	31
27-Jul	12	6	18
28-Jul	10	4	14
29-Jul	9	1	10
30-Jul	12	1	13
31-Jul	8	0	8
01-Aug	8	0	8
02-Aug	0	0	0
03-Aug	7	1	8
04-Aug	0	0	0
05-Aug	1	1	2
06-Aug	4	4	8
07-Aug	0	1	1
08-Aug	3	0	3
09-Aug	4	2	6
10-Aug	1	1	2
11-Aug	3	1	4
12-Aug	4	1	5
13-Aug	5	0	5
14-Aug	2	0	2
15-Aug	2	0	2
16-Aug	4	1	5
17-Aug	2	0	2
18-Aug	2	0	2
19-Aug	1	0	1
20-Aug	1	2	3
21-Aug	2	0	2
22-Aug	1	1	2
23-Aug	4	0	4
24-Aug	2	0	2
25-Aug	1	0	1
26-Aug	1	0	1
27-Aug	0	0	0
28-Aug	0	0	0
29-Aug	1	0	1
30-Aug	0	0	0
31-Aug	0	0	0
01-Sep	3	0	3
02-Sep	1	0	1
03-Sep	0	0	0
04-Sep	1	0	1
05-Sep	0	0	0
06-Sep	0	0	0
07-Sep	0	0	0
08-Sep	0	0	0
Total	3275	402	3677

Table 6. Number by standard week for upstream migration of adult Atlantic salmon through the counting facility on the Campbellton River, 1993-98.

Dates		Standard week	1993		1994		1995		1996		1997		1998		1993 - 98				
			Small	Large	Small	Large	Small	Large	Small	Large	Small	Large	Small	Large	Small	Large	Total	Mean	Percent
May	28-03	22											0	0	0	0	0	0	0.00
June	04-10	23							33	9			27	7	60	16	76	13	0.38
	11-17	24	14	0	3	0	4	2	405	42	16	6	156	33	598	83	681	114	3.37
	18-24	25	217	6	234	28	322	28	729	57	317	16	1,813	59	3,632	194	3,826	638	18.95
	25-01	26	1,023	40	525	11	867	30	737	97	450	12	525	27	4,127	217	4,344	724	21.52
July	02-08	27	1,351	42	721	22	693	13	645	161	284	1	199	46	3,893	285	4,178	696	20.70
	09-15	28	727	25	353	15	279	4	439	120	113	19	266	146	2,177	329	2,506	418	12.41
	16-22	29	340	12	215	19	394	35	93	46	42	10	86	30	1,170	152	1,322	220	6.55
	23-29	30	155	7	538	47	297	45	69	18	180	51	112	37	1,351	205	1,556	259	7.71
August	30-05	31	59	1	118	18	78	23	37	6	18	9	36	3	346	60	406	68	2.01
	06-12	32	53	4	114	17	39	23	10	3	18	8	19	10	253	65	318	53	1.58
	13-19	33	25	3	16	7	40	11	11	1	258	109	18	1	368	132	500	83	2.48
	20-26	34	17	2	13	1	19	4			34	11	12	3	95	21	116	19	0.57
	27-02	35	12	0	3	3	3	0			230	64	5	0	253	67	320	53	1.59
September	03-09	36	8	3	4	3					15	5	1	0	28	11	39	7	0.19
Total			4,001	145	2,857	191	3,035	218	3,208	560	1,975	321	3,275	402	18,351	1,837	20,188	3,365	
Percent			96.5	3.5	93.7	6.3	93.3	6.7	85.1	14.9	86.0	14.0	89.1	10.9	90.9	9.1			
Start date for fence			10-Jun		13-Jun		14-Jun		03-Jun		13-Jun		01-Jun						
End date for fence			07-Sep		12-Sep		29-Aug		20-Aug		08-Sep		08-Sep						

Table 7. Sea and freshwater survival rates for adult salmon from Campbellton River, 1994-98. Year is year of 1SW adult return.

Percent Survival	1998	1997	1996	1995	1994	Mean % 94-98
Smolt to Small salmon uncorrected	5.28	3.38	8.08	7.28	9.05	6.61
Smolt to small salmon corrected	4.94	2.25	7.15	6.08	7.24	5.53
Percent difference (uncorrected to corrected)	6.44	33.43	11.51	16.48	20.00	16.36
Overwintering of previous spawners in freshwater	71.30	70.05	68.92	69.20	74.10	70.71
Previous spawners survival (<3 months) at sea	33.17	38.96	39.42	34.85	25.58	34.40

Due to the late installation of the smolt fence in 1998 the kelt migration was derived from data of previous years.

Table 8a. River age and percent of sampled smolts from 1993-98 applied to the downstream smolt migrations for Campbellton River, 1993-98.

	River age											
	2		3		4		5		6			
Year	No.	%	No.	%	No.	%	No.	%	No.	%	Total enumerated at fence	Total sampled
93	0	0.00	15,710	49.75	15,233	48.24	635	2.01	0	0.00	31,577	199
94	171	0.41	25,931	[illegible]	12,620	30.29	2,766	6.64	171	0.41	41,663	241
95	191	0.48	24,774	62.38	13,805	34.76	945	2.38	0	0.00	39,715	210
96	671	1.15	34,975	59.92	20,050	34.35	2,673	4.58	0	0.00	58,369	262
97	230	0.37	35,685	57.51	24,547	39.56	1,365	2.20	230	0.37	62,050	273
98	217	0.43	22,946	45.49	25,326	50.21	1,947	3.86			50,441	233
Mean	232	0.49	26,688	56.42	18,580	39.28	1,736	3.67	66	0.14	47,303	236

Table 8b. Mean fork length, whole weight and river age of salmon smolts sampled from the smolt fence at Campbellton River, 1993-98.

Sex	Fork length (cm)					Whole weight (grams)					Mean river age (yrs)				
	Mean	Nunber	STD	Min.	Max.	Mean	Number	STD	Min.	Max.	Mean	Nunber	STD	Min.	Max.
Male	17.3	395	1.9	13.3	27.5	47.6	395	18.1	18.9	188.2	3.5	393	0.6	3	6
Female	17.3	1030	2.1	12.2	27.8	49.1	1030	19.9	17.5	206.9	3.4	1025	0.6	2	6
All	17.3	1425	2.0	12.2	27.8	48.7	1425	19.4	17.5	206.9	3.5	1418	0.6	2	6

Table 9. Biological characteristics of small salmon sampled in the recreational fishery at Campbellton River, 1992-98.

		Fork length (cm)					Whole weight (kgs)					River age (years)				
Year	Sex	Mean	Number	STD	Min	Max	Mean	Number	STD	Min	Max	Mean	Number	STD	Min	Max
92	Male	55.88	4	3.97	52.0	60.0	1.83	3	0.58	1.50	2.50	3.50	4	1.00	3	5
	Female	53.85	13	4.93	43.5	62.5	1.75	2		1.75	1.75	3.38	13	0.51	3	4
	All	54.18	17	4.71	43.5	62.5	1.81	4	0.47	1.50	2.50	3.41	17	0.62	3	5
93	Male	53.03	23	3.50	48.0	62.0	1.55	23	0.29	1.16	2.50	3.09	23	0.29	3	4
	Female	52.42	64	2.49	46.0	57.5	1.47	61	0.22	0.76	1.92	3.03	61	0.36	2	4
	All	52.58	87	2.78	46.0	62.0	1.49	84	0.25	0.76	2.50	3.05	84	0.34	2	4
94	Male	55.76	10	3.13	52.5	60.5	1.79	10	0.36	1.40	2.31	3.17	12	0.39	3	4
	Female	52.71	31	3.13	46.3	59.5	1.56	28	0.28	0.94	2.16	3.25	32	0.51	3	5
	All	53.45	41	3.36	46.3	60.5	1.62	38	0.31	0.94	2.31	3.23	44	0.48	3	5
95	Male	53.89	10	3.55	49.0	61.0	1.72	9	0.38	1.13	2.30	3.30	10	0.48	3	4
	Female	52.47	45	3.44	43.0	62.0	1.55	38	0.32	0.97	2.42	3.30	44	0.51	2	4
	All	52.89	55	3.46	43.0	62.0	1.58	47	0.33	0.97	2.42	3.30	54	0.50	2	4
96	Male	50.83	3	1.87	48.5	52.0	1.44	3	0.10	1.33	1.50	3.50	2	0.71	3	4
	Female	51.50	6	4.23	45.0	55.0	1.58	5	0.41	1.10	2.10	3.33	6	0.52	3	4
	All	51.21	9	3.50	45.0	55.0	1.53	8	0.33	1.10	2.10	3.38	8	0.52	3	4
97	Male	53.05	4	3.81	49.5	58.0	1.66	4	0.35	1.23	2.00	3.50	4	0.58	3	4
	Female	52.08	18	3.96	40.0	56.5	1.43	17	0.28	0.91	1.93	3.33	18	0.49	3	4
	All	52.26	22	3.86	40.0	58.0	1.48	21	0.30	0.91	2.00	3.36	22	0.49	3	4
98	Male	54.50	2	2.12	53.0	56.0	1.69	2	0.15	1.58	1.80	3.50	2	0.71	3	4
	Female	53.30	21	2.66	49.5	60.0	1.53	20	0.23	1.13	2.04	3.44	18	0.51	3	4
	All	53.40	23	2.60	49.5	60.0	1.54	22	0.30	1.13	2.04	3.45	20	0.51	3	4
92-98	Male	53.76	54	3.50	48.0	62.0	1.64	54	0.34	1.13	2.50	3.23	57	0.46	3	5
	Female	52.60	198	3.21	40.0	62.5	1.51	170	0.27	0.76	2.42	3.23	192	0.48	2	5
	All	52.85	254	3.31	40.0	62.5	1.54	224	0.29	0.76	2.50	3.23	249	0.47	2	5

Table 10. River age and percent of salmon sampled in the recreational fishery or the adult counting fence at Campbellton River, 1992-98.

		River age								
		2		3		4		5		
Year	Size	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Total
1992	small	1	4.55	15	68.18	5	22.73	1	4.55	22
1993	small	4	4.60	75	86.21	8	9.20	0	0.00	87
1994	small	0	0.00	35	79.55	8	18.18	1	2.27	44
1995	small	1	1.85	36	66.67	17	31.48	0	0.00	54
1996	small	0	0.00	5	55.56	4	44.44	0	0.00	9
1997	small	0	0.00	14	63.64	8	36.36	0	0.00	22
1998	large	0	0.00	17	62.96	7	25.93	3	11.11	22
	small	0	0.00	19	47.50	17	42.50	4	10.00	27
Total		6	1.97	216	70.82	74	24.26	9	2.95	305

Table 11. Percent male and female of salmon sampled in the recreational fishery at Campbellton River, 1992-98.

	Male		Female	
Year	Number	Percent	Number	Percent
92	4	23.53	13	76.47
93	23	26.44	64	73.56
94	12	27.27	32	72.73
95	10	18.18	45	81.82
96	3	33.33	6	66.67
97	4	18.18	18	81.82
98	2	8.33	22	91.67
Mean	58	22.57	199	77.43

Table 12. Campbellton River adult salmon returns, spawning escapment and egg deposition, 1993-98.

SPAWNING ESCAPEMENT $SE = (FR - RCT) - (HRM)$

SE= Spawning escapment
FR= Fish released by counting fence
RCT= Recreational catch (retained)
RCL= Recreational catch (released)
HRM= Recreational mortality (RCL *0.1)

		1993	1994	1995	1996	1997	1998	Average
FR	Small	4001	2857	3035	3208	1975	3275	3059
	Large	145	191	218	560	321	402	306
RCL	Small	103	4	47	93	67	250	94
	Large	0	1	1	31	9	8	8
HRM	Small	10	0	5	9	7	25	9
	Large	0	0	0	3	1	1	1
RCT	Small	316	340	393	463	254	315	347
	Large	0	0	0	0	0	0	0
SE	Small	3675	2517	2637	2736	1714	2935	2702
	Large	145	191	218	557	320	401	305

EGG DEPOSITION $ED = SE * PF * RF * MW$

ED= Egg deposition
SE= Spawning escapment
PF= Proportion females
RF= Relative fecundity (eggs/kg)
MW= Mean weight of females

	Year	1993	1994	1995	1996	1997	1998	AVERAGE
SE	Small	3675	2517	2637	2736	1714	2935	2702
	Large	145	191	218	557	320	401	305
PF	Small	0.736	0.727	0.818	0.667	0.818	0.774 *	0.757
	Large	0.769	0.769	0.769	0.769	0.769	0.769	0.769
RF	Small	2100	2100	2100	2100	2100	2100	2100
	Large	2100	2100	2100	2100	2100	2100	2100
MW	Small	1.47	1.56	1.55	1.58	1.43	1.51 *	1.52
	Large	3.13	3.13	3.13	3.13	3.13	3.13	3.13
ED	Small	8344498	5996139	7023765	6051671	4211099	7203529	6471784
	Large	732922	964930	1101405	2814927	1617989	2027920	1543349
	Total	9077421	6961069	8125171	8866598	5829088	9231449	8015133
Conservation requirement		2916000	2916000	2916000	2916000	2916000	2916000	2916000
% requirements		311	239	279	304	200	317	275

The PF and MW for large salmon are default values calculated from several rivers in Notre Dame Bay (O'Connell et al.1996).

* Due to the low recreational sampling base (24 fish) in 1998 the mean MW and PF derived from 1992-98 were used.

Table 13a. Summary of assessment of Campbellton River salmon stock based on upstream migrating adults. Based on a conservation requirement of 2,916,000 eggs.

	Fence count		Angling catch and mortality at 10%				Spawning escapement		Mean WW female		Percent female		Fecundity (eggs/kg)		Egg deposition			Percent of conservation requirement
Year	Small	Large	Small	Mortality	Large	Mortality	Small	Large	Small	Large	Small	Large	Small	Large	Small	Large	Total	
93	4001	145	316	10	0	0	3675	145	1.47	3.13	73.56	76.90	2100	2100	8,345,180	732,922	9,078,102	311
94	2857	191	340	0	0	0	2517	191	1.56	3.13	72.73	76.90	2100	2100	5,997,092	965,436	6,962,527	239
95	3035	218	393	5	0	0	2637	218	1.55	3.13	81.82	76.90	2100	2100	7,022,967	1,101,911	8,124,877	279
96	3208	560	463	9	0	3	2736	557	1.58	3.13	66.67	76.90	2100	2100	6,052,335	2,815,433	8,867,767	304
97	1975	321	254	7	0	1	1714	320	1.43	3.13	81.82	76.90	2100	2100	4,211,392	1,617,484	5,828,875	200
98	3275	402	315	25	0	1	2935	401	1.51	3.13	77.4	76.9	2100	2100	7,203,529	2,026,909	9,230,438	317

Table 13b. Summary of assessment of Campbellton River salmon stock based on downstream migrating kelts from the next year. Based on a conservation requirement of 2,916,000 eggs.

	Fence count		Angling catch and mortality at 10%				Spawning escapement		Mean WW female		Percent female		Fecundity (eggs/kg)		Egg deposition			Percent of conservation requirement
Year	Small	Large	Small	Mortality	Large	Mortality	Small	Large	Small	Large	Small	Large	Small	Large	Small	Large	Total	
93	4001	145	316	10	0	0	3675	145	52.03	65.17	73.56	76.90	59.97	59.97	8,435,036	435,789	8,870,825	304
94	2857	191	340	0	0	0	2517	191	53.25	65.00	72.73	76.90	59.97	59.97	5,845,888	572,542	6,418,429	220
95	3035	218	393	5	0	0	2637	218	52.33	68.37	81.82	76.90	59.97	59.97	6,771,025	687,357	7,458,382	256
96	3208	560	463	9	0	3	2736	557	52.04	69.03	66.67	76.90	59.97	59.97	5,692,695	1,773,183	7,465,877	256
97	1975	321	254	7	0	1	1714	320	52.35	68.07	81.82	76.90	59.97	59.97	4,402,720	1,004,537	5,407,257	185
98	3275	402	315	25	0	1	2935	401			77.4	76.90	59.97	59.97				

Note: Mean fork length of kelts are applied to the previous year data to represent upstream migrating fish.

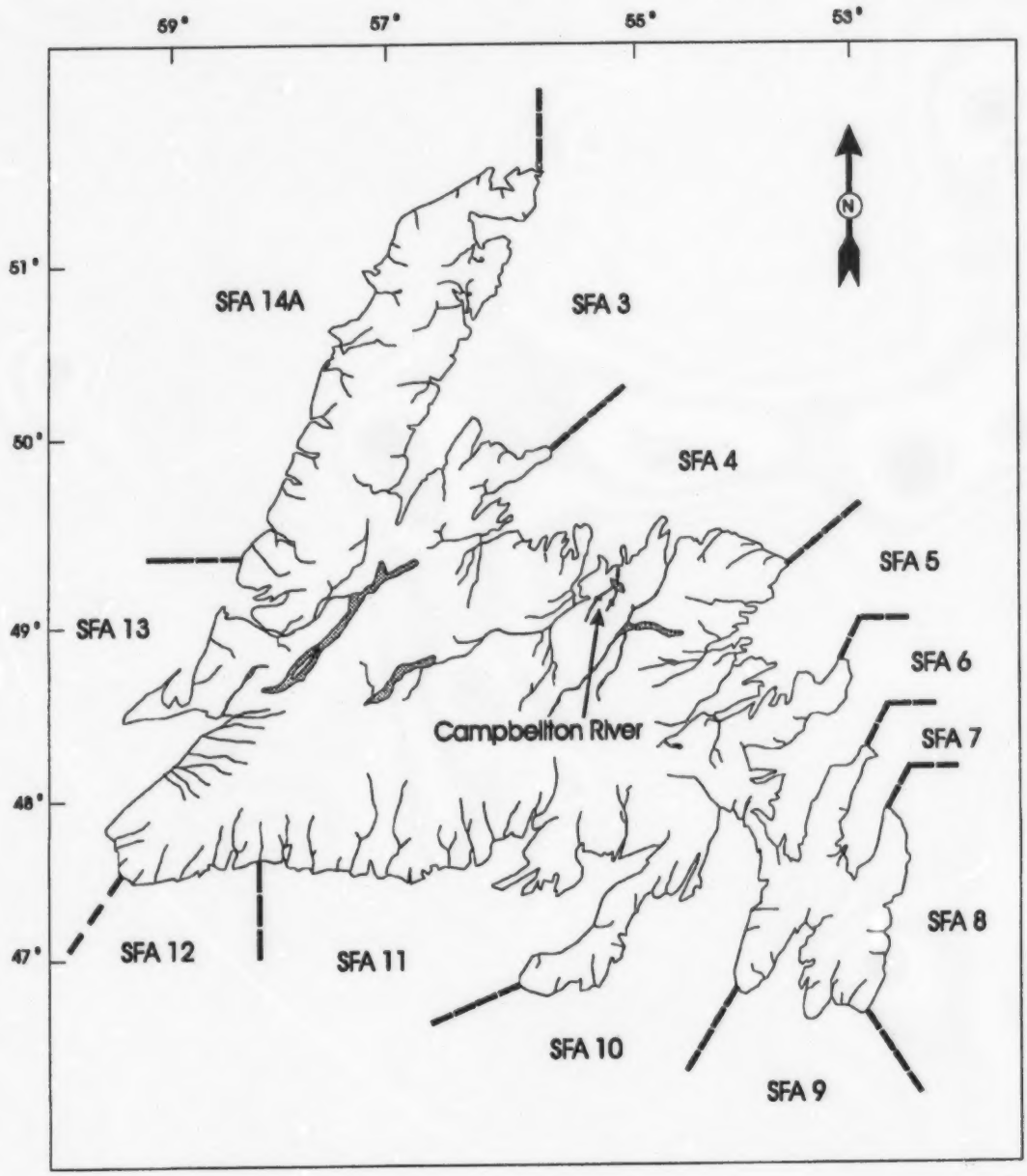

Figure 1. Salmon Fishing Areas on the Island of Newfoundland with reference to the the Campbellton River.

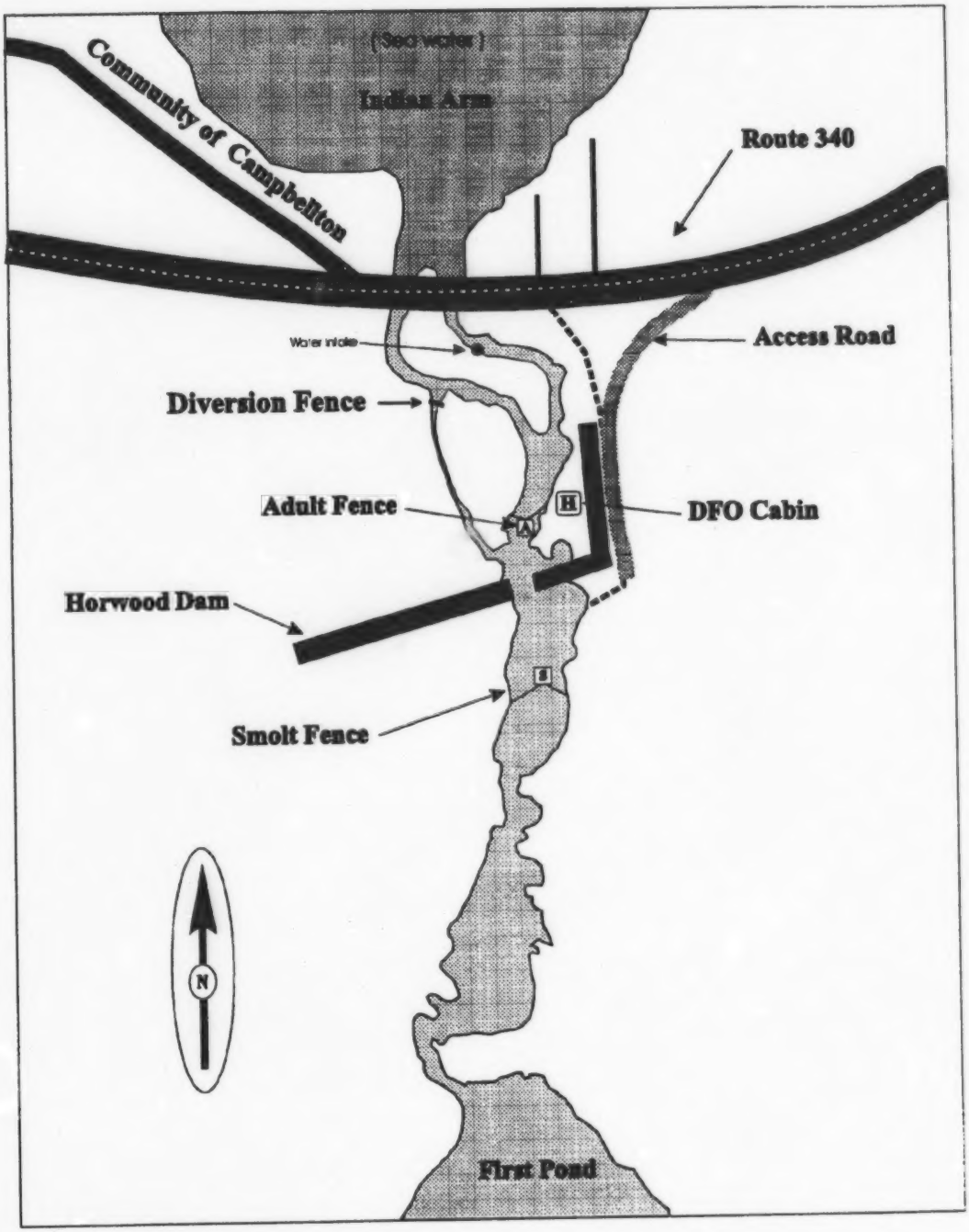

Figure 2. Campbellton River showing locations of smolt and adult counting fences.

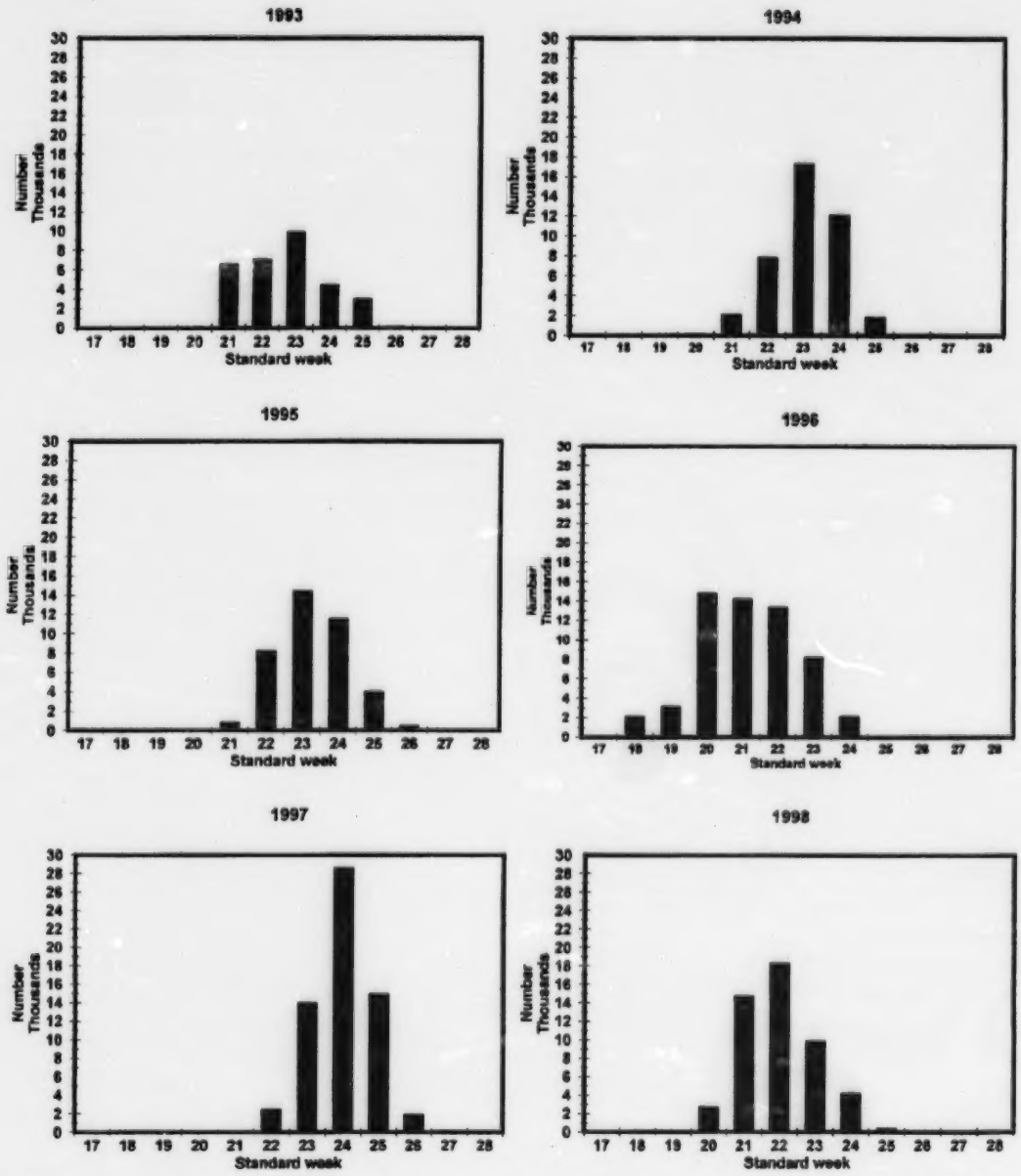

Figure 3. Downstream smolt migration at Campbellton River, 1993 - 98.

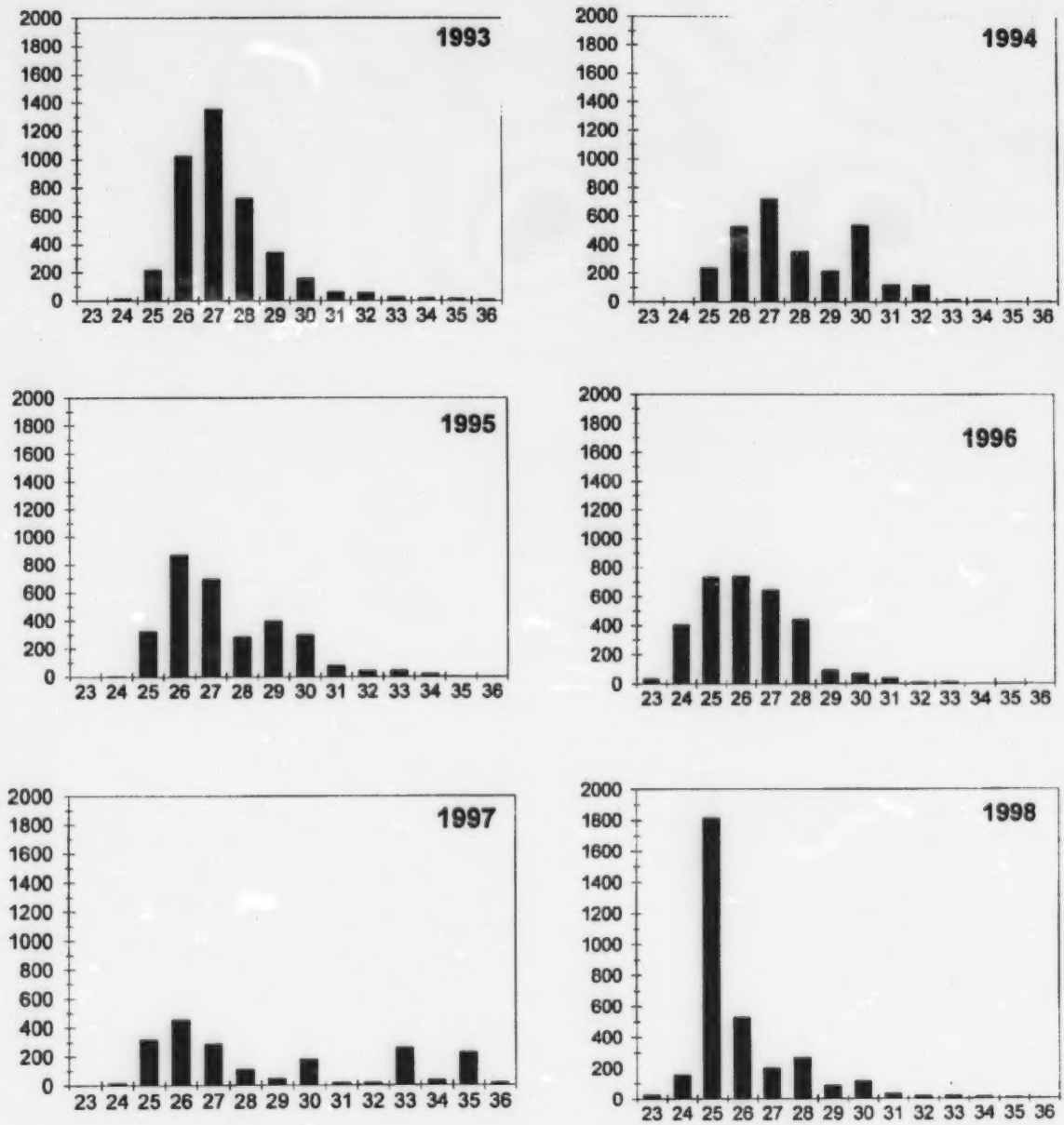

Figure 4. Adult small salmon upstream migrations enumerated at the counting fence, Campbellton River, 1993-98.

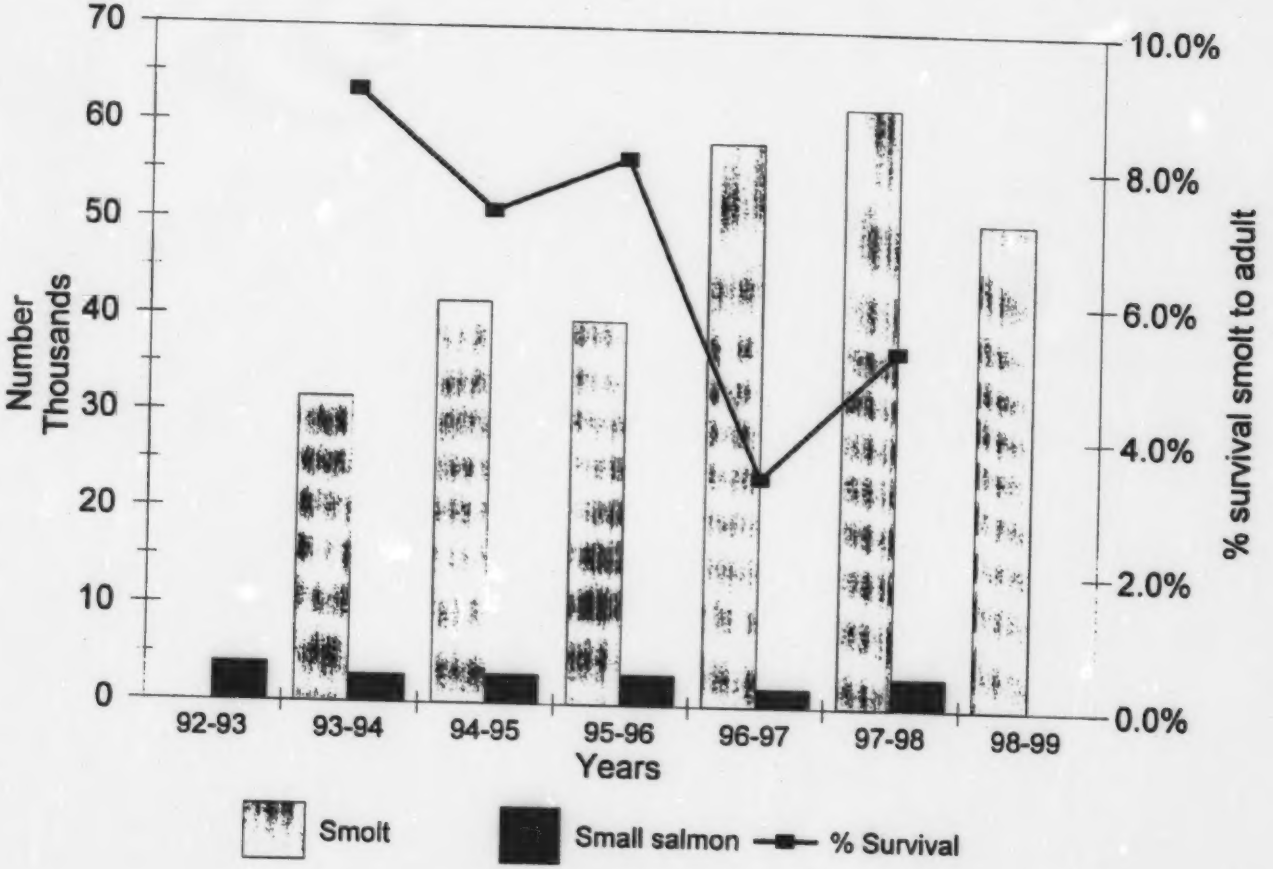

Figure 5. Smolt and small salmon migrations with survival rate (uncorrected for previous spawners) for Campbellton River, 1993-98.

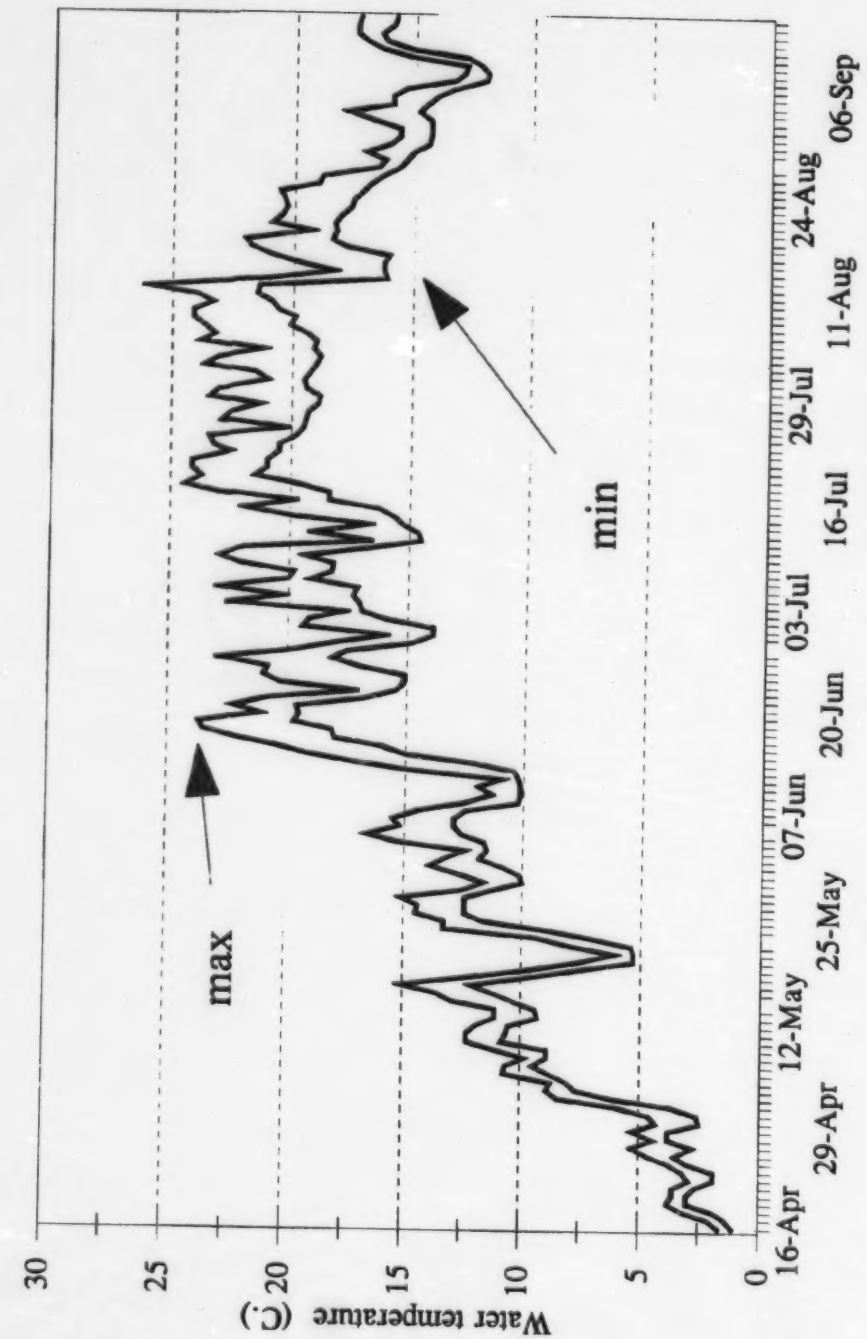

Figure 6. Minimum and maximum daily water temperatures for Campbellton River, 1998.

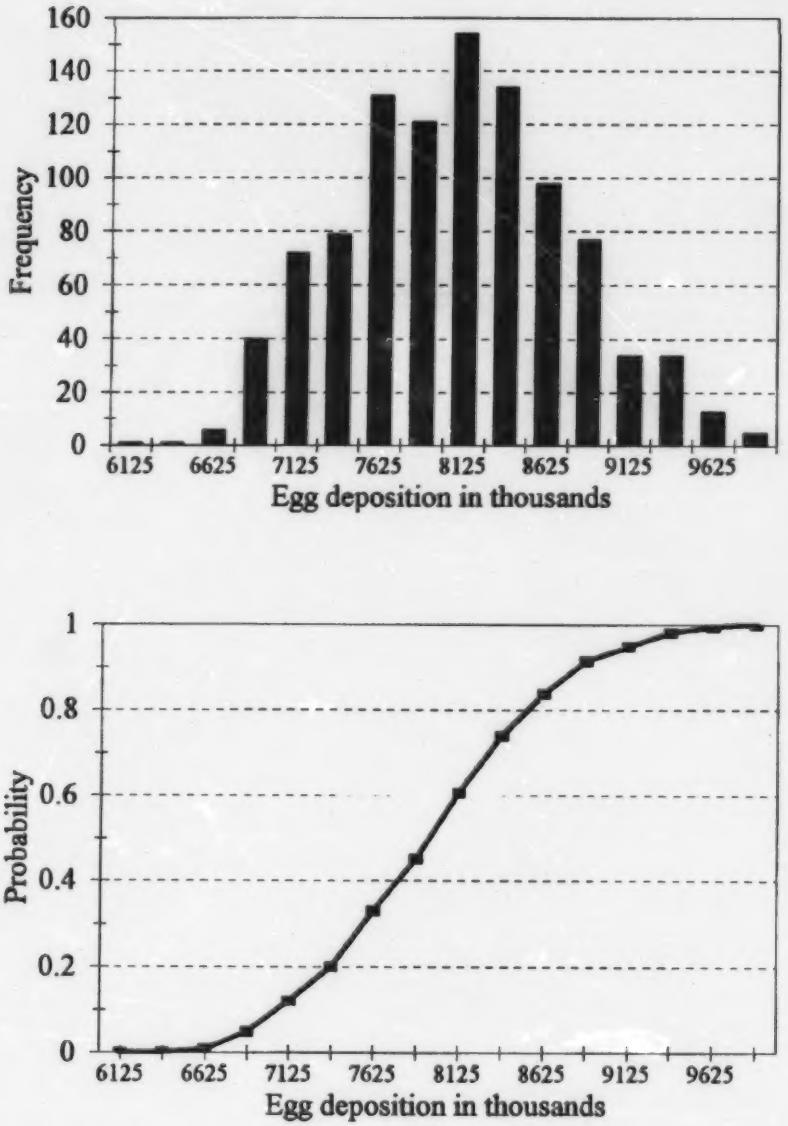

Fig. 7. Frequency distribution of the estimated egg deposition at Campbellton River, 1998 (upper panel) and the corresponding probability distribution (lower panel). The analysis with 1000 realizations assumed a 20% coefficient of variation around proportion female, relative fecundity, and mean weight of the small and large salmon components. Egg deposition are in thousands at the mid-point of each interval.

APPENDIX I

Sea survival rates for Campbellton River salmon

1994

Sea survival rates for 93 smolt class:

Smolt count - 93		= 31,577
Adult count (small only) - 94		= 2,857
Sea survival rate - 93	*(2,857 / 31,577)*	= 9.05 % (uncorrected)

Previous spawners:

Kelts (downstream) - 94		= 2,838
Tagged kelts (downstream) - 94 (first year of kelt tagging)		= 942
Ratio untagged : tagged (total)	*(2,838 / 942)*	= 3.01
Overwintering survival- 93 to 94 with the recreational catch removed	*(2,838 / (4,146-316))*	= 74.10 %

The following table is a summary of the estimated numbers of previous spawners in small and large categories:

	UPSTREAM MIGRATIONS			
	Tagged	Est. previous spawners	Total '94	Percent previous spawners
Small	190	572	2,857	20.0
Large	51	154	191	80.6
Total	241	726	3,048	23.8

Sea survival rates with correction for previous spawners:

Smolt count - 93		= 31,577
Upstream grilse - 94	*(2,857-572)*	= 2,285
Previous spawners survival 3 mo	*(726 / 2,838)*	= 25.58 %
Corrected smolt sea survival - 93	*(2,285 / 31,577)*	= 7.24 %

APPENDIX 2

Sea survival rates for Campbellton River salmon

1995

Sea survival rates for 94 smolt class:

Smolt count - 94		= 41,663
Adult count (small only) - 95		= 3,035
Sea survival rate - 94	*(3,035 / 41,663)*	= 7.28 % (uncorrected)

Previous spawners:

Kelts (downstream) - 95		= 1,874
Tagged kelts (downstream) - 95 (448 tagged in '95 & 152 from '94)		= 600
Ratio untagged : tagged (total)	*(1,874 / 600)*	= 3.12
Overwintering survival- 94 to 95 with the recreational catch removed	*(1,874 / (3,048-340))*	= 69.20 %

The following table is a summary of the estimated numbers of previous spawners in small and large categories:

	UPSTREAM MIGRATIONS			
	Tagged	Est. previous spawners	Total '95	Percent previous spawners
Small	160	500	3,035	16.5
Large	49	153	218	70.2
Total	209	653	3,253	20.1

Sea survival rates with correction for previous spawners:

Smolt count - 94		= 41,663
Upstream grilse - 95	*(3,035-500)*	= 2,535
Previous spawners survival 3 mo	*(653 / 1,874)*	= 34.85 %
Corrected smolt sea survival - 94	*(2,535 / 41,663)*	= 6.08 %

APPENDIX 3

Sea survival rates for Campbellton River salmon

1996

Sea survival rates for 95 smolt class:

Smolt count - 95		= 39,715
Adult count (small only) - 96		= 3,208
Sea survival rate - 95	*(3,208 / 39,715)*	= 8.08 % (uncorrected)

Previous spawners:

Kelts (downstream) - 96		= 1,971
Tagged kelts (downstream) - 96 (484 tagged in '96 & 100 from '94-95)		= 584
Ratio untagged : tagged (total)	*(1,971 / 584)*	= 3.38
Overwintering survival- 95 to 96 with the recreational catch removed	*(1,971 / (3,253-393))*	= 68.92 %

The following table is a summary of the estimated numbers of previous spawners in small and large categories:

	UPSTREAM MIGRATIONS			
	Tagged	Est. previous spawners	Total '96	Percent previous spawners
Small	109	368	3,208	11.5
Large	121	409	560	73.0
Total	230	777	3,768	20.6

Sea survival rates with correction for previous spawners:

Smolt count - 95		= 39,715
Upstream grilse - 96	*(3,208-368)*	= 2,840
Previous spawners survival 3 mo	*(777 / 1,971)*	= 39.42 %
Corrected smolt sea survival - 95	*(2,840 / 39,715)*	= 7.15 %

APPENDIX 4

Sea survival rates for Campbellton River salmon

1997

Sea survival rates for 96 smolt class:

Smolt count - 96		= 58,369
Adult count (small only) - 97		= 1,975
Sea survival rate - 96	*(1,975 / 58,369)*	= 3.38 % (uncorrected)

Previous spawners:

Kelts (downstream) - 97		= 2,315
Tagged kelts (downstream) - 97 (347 tagged in '97 & 112 from '94-96)		= 459
Ratio untagged : tagged (total)	*(2,315 / 459)*	= 5.04
Overwintering survival- 96/97 with the recreational catch removed	*(2,315 / (3,768-463))*	= 70.05%

The following table is a summary of the estimated numbers of previous spawners in small and large categories:

	UPSTREAM MIGRATIONS			
	Tagged	Est. previous spawners	Total '97	Percent previous spawners
Small	131	660	1,975	33.4
Large	48	242	321	75.4
Total	179	902	2,296	39.3

Sea survival rates with correction for previous spawners:

Smolt count - 96		= 58,369
Upstream grilse - 97	*(1,975-660)*	= 1,135
Previous spawners survival 3 mo	*(902 / 2,315)*	= 38.96%
Corrected sea smolt survival - 96	*(1,315 / 58,369)*	= 2.25%

APPENDIX 5

Sea survival rates for Campbellton River salmon

1998

Sea survival rates for 97 smolt class:

Smolt count - 97		= 62,050
Adult count (small only) - 98		= 3,275
Sea survival rate - 97	*(3,275 / 62,050)*	= 5.28 % (uncorrected)

Previous spawners:

Kelts (downstream) - 98		= 351 (1,456)
Tagged kelts (downstream) - 98 (109 tagged in '98 & 19 + *x* from '94-97)		= 128 (274)
Ratio untagged : tagged (total)	*(351 / 128)* or *(1456/274)*	= 2.74 (5.31)
Over-wintering survival- 97/98 with the recreational catch removed	*(351 / (2296-254)* *or (1,456/ (2296-254)*	= 17.19% (71.30)

The following table is a summary of the estimated numbers of previous spawners in small and large categories using previous spawners actual counts and derived figures:

	UPSTREAM MIGRATIONS			
	Tagged	Est. previous spawners	Total '98	Percent previous spawners
Small	40	112 (212)	3,275	3.4 (6.47)
Large	51	143 (271)	402	35.6 (67.4)
Total	91	255 (483)	3,677	6.9 (13.1)

Sea survival rates with correction for previous spawners:

Smolt count - 97		= 62,050
Upstream grilse - 98	*(3,275-112)*	= 3,163 (3,063)
Previous spawners survival 3 mo	*(255 / 351)*	= 72.65% (33.17)
Corrected sea smolt survival - 97	*(3,163 / 62,050)*	= 5.10% (4.94)

Note: Due to the late installation of the smolt fence, downstream kelt counts appear to be incomplete, therefore the kelt migration and those with tags attached were calculated by using ratios of kelt migrations and tagging from previous years. These derived figures used in the above calculations are indicated with brackets.

Appendix 6

STOCK: Campbellton River (SFA 4) **Drainage area:** 296 km^2 (accessible)

CONSERVATION REQUIREMENT: 2.916 million eggs (~1480 small salmon) calculated as fluvial area x 2.4 eggs/m^2 and lacustrine area x 368 eggs per hectare.

Year	1993	1994	1995	1996	1997	1998	MIN[1]	MAX[1]
Total returns to the river								
Small	4001	2857	3035	3208	1975	3275	1975	4001
Large	145	191	218	560	321	402	145	560
Recreational harvest (small salmon)								
Retained	316	340	393	463	254	315	23	1547
Released	103	4	47	93	67	250	4	250
Recreational harvest (large salmon)								
Retained	-	-	-	-	-	-	0	63
Released	0	1	1	31	9	8	0	31
Spawners								
Small	3675	2517	2637	2736	1714	2935	1714	3675
Large	145	191	218	557	320	401	145	557
Egg conservation requirement								
% met	311	239	279	304	200	317	200	317
Smolt count	31577	41633	39715	58369	62050	50441	31577	62050
% Sea survival								
(adult return year)		7.2	6.1	7.2	2.3	4.9	2.3	7.2

[1] Min and max are for the period of record since 1974.
[2] Preliminary.

Data and methodology: Smolts were enumerated at a counting fence. Returning adult salmon are enumerated at a fish counting fence with a video camera system. A hook-and-release mortality rate of 10% was used in the calculation of spawning escapements for the years 1993-98. Recreational data for 1997-98 were from the License Stub Return System and are preliminary. Sea survival is corrected to exclude previous spawners in the upstream migration. Previous spawners were estimated in 1998 from survival patterns in previous years. Egg conservation requirement met was calculated using average percent female and average whole weight, 1993-98 due to the low number of samples obtained from the angling fishery.

State of the stock: Conservation requirements were met from 1993 to 1998.

Forecast: No forecast available.